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THESIS

APPLICATION OF THE CONTINUOUS ACQUISITION AND LIFE-CYCLE SUPPORT (CALS) INITIATIVE TO THE EVOLVED SEASPARROW MISSILE PROGRAM

by

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This thesis reviews the Continuous Acquisition and Life-cycle Support (CALS) initiative and its data format specifications and analyzes how they were applied to the Evolved SEASPARROW Missile (ESSM) Program. The CALS initiative and its data format specifications were developed to facilitate management of defense system technical data. With recent reforms in defense acquisition policy called for in Secretary of Defense memorandum, "Specifications & Standards - A New Way of Doing Business" their application to defense system procurements has been questioned.

Following a review of the CALS initiative and its data format specifications, an analysis of the application of the CALS initiative to the ESSM program is presented. Additionally, the information technology infrastructure at the Navy's weapon system In-service Support Engineering Agent (ISEA), Port Hueneme Division, Naval Surface Warfare Center is presented, and analyzed on its suitability to handle CALS-compliant data formats.

This research concludes that the CALS initiative and its data format specifications should be reviewed as to their application to the Engineering and Manufacturing Development phase contract of the ESSM Program. Furthermore, this research concludes that the information infrastructure at the ISEA is not fully prepared to handle technical data in CALS-compliant data formats. Finally, specific recommendations are made on how the Government should structure its Data Management Plan to convey to the prime contractor how it intends to manage technical data.

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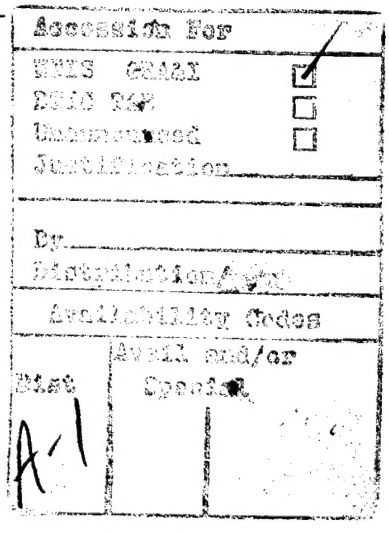

ABSTRACT

This thesis reviews the Continuous Acquisition and Life-cycle Support (CALS) initiative and its data format specifications and analyzes how they were applied to the Evolved SEASPARROW Missile (ESSM) Program. The CALS initiative and its data format specifications were developed to facilitate management of defense system technical data. With recent reforms in defense acquisition policy called for in Secretary of Defense memorandum, "Specifications & Standards - A New Way of Doing Business" their application to defense system procurements has been questioned.

Following a review of the CALS initiative and its data format specifications, an analysis of the application of the CALS initiative to the ESSM program is presented. Additionally, the information technology infrastructure at the Navy's weapon system In-service Support Engineering Agent (ISEA), Port Hueneme Division, Naval Surface Warfare Center is presented, and analyzed on its suitability to handle CALS-compliant data formats.

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I. INTRODUCTION

A. BACKGROUND

This research emanates from the conflict between the defense acquisition manager's desire for delivery of weapon system technical data in non-proprietary, open formats and recent changes in Department of Defense (DoD) acquisition policy. In the past, technical data such as engineering drawings, illustrations, and textual data for a weapon system was delivered to the Government in paper form. This made it necessary for DoD activities involved in managing the acquisition of a weapon system to orient their processes around handling paper-based documentation. These processes, however, were slow, error-prone and manpower intensive.

In the mid 1980's the DoD sought to capitalize on advances in computer hardware and in the areas of computer-aided design, computer-aided engineering, and concurrent engineering. DoD structured a series of military specifications and standards that facilitated the handling of weapon system technical data in open, digital formats. This initiative grew into a joint DoD-industry Continuous Acquisition and Life-cycle Support (CALS) initiative and led to acquisition processes between defense contractors and DoD acquisition managers being conducted with technical data in digital formats. With this change, there came a need for data management systems that could receive, store, and manipulate technical data in its various formats. Additionally, many of the acquisition management processes required "reengineering" using concepts such as Business Process Reengineering in order to truly reap the benefits of receiving, handling, and managing technical data in digital formats.

With the recent changes in acquisition policy since Secretary of Defense, William J. Perry's memorandum, "Specifications & Standards - A New Way of Doing Business," the application of the CALS initiative and its data format specifications to DoD weapon system procurements is now in question. Specifically, Secretary Perry called for the "use of performance and commercial specifications and standards in lieu of military specifications and standards, unless no practical alternative exists to meet the user's needs." (DoD OSD, 1994, pg. 1)

B. THESIS OBJECTIVES

The primary objective of this research is to determine whether the Continuous Acquisition and Life-cycle Support (CALS) initiative and its data format specifications should have been applied to the Engineering and Manufacturing Development (EMD) contract for the Evolved SEASPARROW Missile (ESSM) program. To achieve this objective, this research assesses: (1) the CALS initiative strategies, objectives and data format specifications, (2) how the ESSM program office applied the CALS initiative and their data format specifications, and (3) the information technology (IT) infrastructure at the Navy's weapon system In-service Support Engineering Agent (ISEA), Port Hueneme Division, Naval Surface Warfare Center (PHD-NSWC).

C. RESEARCH QUESTIONS

This thesis attempts to answer the following research questions:

1. Primary Research Question

Should the CALS initiative and its data format specifications have been applied to the ESSM program's EMD phase contract?

2. Secondary Research Questions

- Is the IT infrastructure at the ESSM ISEA adequate to support the management of the technical data for the Evolved SEASPARROW Missile during the life-cycle of the weapon system?
- How could the ESSM program office structure the Data Management Plan for the EMD phase contract to convey to the prime contractor how the Government intends to manage the technical data associated with the weapon system?

D. SCOPE OF THESIS

This thesis analyzes the CALS initiative and its new strategies and objectives made public in October 1993. It also presents the two "flagship" CALS infrastructure modernization systems Joint Computer-aided Acquisition and Logistics Support (JCALS)

and Joint Engineering Data Management Information Control System (JEDMICS) and analyzes the four CALS Data Format Specifications.

The Navy's ESSM program's efforts to apply the CALS initiative and its data format specifications will be presented through the acquisition planning and source selection phases of the program. This thesis does not address how the ESSM program intends to implement the CALS initiative during management of the ESSM EMD phase contract. Instead, it offers recommendations on how the Government should structure its data management plan to ensure complete coverage of all relevant technical data issues with the prime contractor.

This thesis includes an analysis of the information technology infrastructure at the Navy's ISEA for surface ship weapon systems, PHD-NSWC. The focus is on whether PHD-NSWC is capable of performing its functions as the ISEA for the ESSM if the contractor-delivered technical data is in CALS-compliant technical data formats.

E. LITERATURE REVIEW AND RESEARCH METHODOLOGY

The research on the CALS initiative is primarily a review and analysis of CALS documents that have been issued by the DoD CALS Policy Office. Department of Navy activities that have responsibility for interpreting the CALS initiative and providing implementation guidance on the initiative for Navy and Marine Corps activities is also reviewed and analyzed. Additional insight into how the CALS initiative and its principals are being implemented in defense systems by the U.S. DoD, foreign DoDs, and by numerous domestic and international defense contractors was gained from attendance at the seventh annual CALS Conference and Exposition December 7-9, 1994 in Long Beach, CA. The information on the ESSM Program is drawn from documentation on the program provided by PHD-NSWC and from interviews with PHD-NSWC's ISEA representative for ESSM. The analysis of the IT infrastructure at PHD-NSWC was obtained during three separate visits to Port Hueneme. It is based on open observation of the work environment at PHD-NSWC, direct interaction with the Joint Computer-aided Acquisition and Logistic Support (JCALS) system, and observation of the Integrated Data Management System (IDMS) during a demonstration.

F. CHAPTER OVERVIEWS

This thesis is organized in six chapters. The following is an overview of the remaining chapters.

Chapter II, "Continuous Acquisition and Life-cycle Support Initiative," presents this joint DoD-industry initiative and the two implementations under its infrastructure modernization strategy. Chapter III, "CALS Data Format Specifications," describes the four data format specifications that have been created under the CALS initiative. Chapter IV, "Evolved SEASPARROW Missile Program," presents an overview of the Navy's plans to acquire an upgrade to the RIM-7P surface-to-air missile. Chapter V, "Information Technology Infrastructure at the In-service Support Engineering Agent," describes PHD-NSWC's current technical data management system and plans to integrate that system with portions of the JCALS system. Finally, Chapter VI, "Conclusions and Recommendations for the Management of Technical Data for the ESSM Program," presents several conclusions drawn from this research and discusses issues requiring further research. This chapter also offers recommendations on how issues related to the management of ESSM technical data should be described by the Government to potential contractors.

G. ACRONYMS

This thesis contains numerous acronyms throughout each of the chapters. Listed below are some of the most frequently used acronyms:

CALS	Continuous Acquisition and Life-cycle Support
CDRL	Contract Data Requirements List
CGM	Computer Graphics Metafile
CITIS	Contractor Integrated Technical Information Services
COTS	Commercial Off-The-Shelf
DMP	Data Management Plan
DoD	Department of Defense
DoN	Department of the Navy
EMD	Engineering and Manufacturing Development
ESSM	Evolved SEASPARROW Missile

GCO	Government Concept of Operations
GFI	Government Furnished Information
GOTS	Government-Owned Software
IDMS	Integrated Data Management System
IGES	Initial Graphics Exchange Specification
ISEA	In-service Support Engineering Agent
IT	Information Technology
JCALS	Joint Computer-aided Acquisition and Logistics Support
JEDMICS	Joint Engineering Data Management Information Control System
MAPP	Master Program Plan
NAVSEA	Naval Sea Systems Command
PHD-NSWC	Port Hueneme Division, Naval Surface Warfare Center
PM	Program Manager
RFC	Request For Comment
RFP	Request For Proposal
SGML	Standard Generalized Markup Language
SoW	Statement of Work

II. CONTINUOUS ACQUISITION AND LIFE-CYCLE SUPPORT (CALS) INITIATIVE

This chapter begins by providing background information on the CALS initiative and then describes the current DoD CALS strategic goals. Next, organizations affiliated with CALS and the documentation associated with CALS are presented. These are followed by the CALS implementation strategies and acquisition process guidance. This chapter concludes with descriptions of the two "flagship" CALS initiative implementations: the Joint Continuous Acquisition and Logistics Support (JCALS) program and the Joint Engineering Data Management Information Control System (JEDMICS).

A. BACKGROUND

This background information is taken from Annex 1 of the CALS Strategic Plan published by the DoD CALS & EDI (Electronic Data Interchange) Office in October 1993.

1. CALS Origins

In the mid 1980's, the DoD instituted the Computer-Aided Logistics Support (CALS) initiative as an effort to standardize how technical information should be managed within the department. Advances in computer-aided design, computer-aided manufacturing and computer-aided engineering led defense logisticians to move away from a paper-based technical documentation system to a system where technical information is created, managed and distributed in digital forms. It was thought that the CALS initiative could help the DoD reduce its costs for acquiring technical documentation while making it more accurate, current and timely. In its beginnings, CALS primarily dealt with the logistics of support documentation.

2. CALS Evolution

As the benefits of the CALS initiative became better known, DoD acquisition managers sought to incorporate CALS concepts into weapon systems procurements. In 1988, CALS was renamed the Computer-aided *Acquisition* and Logistics Support

initiative. This better reflected its use in managing the technical information associated with weapon system acquisition.

Developments in the field of Concurrent Engineering (CE) eventually led the CALS initiative to encompass all aspects of weapon system acquisition: design, production and logistics support processes. Similarly, advances in telecommunications such as enterprise networking and digital information exchange protocols led to more technical documentation to be exchanged between businesses. Terms such as electronic commerce and electronic data interchange soon became associated with CALS.

3. CALS Today

Now renamed *Continuous* Acquisition and *Life-cycle* Support, the CALS initiative has been expanded from its roots in technical documentation and logistics support to CE and integrated business processes. It has gained acceptance outside the DoD and defense industries to become a joint DoD-industry managed initiative. The CALS initiative has also been accepted and implemented within international defense departments in Canada, Europe, Asia, and Australia.

4. CALS Vision

The CALS Industry Steering Group has promulgated a vision statement that is quoted below. It was taken from the conference guide to the seventh annual "CALS Expo 94 International" Conference and Exposition.

> The Vision is for all or part of a single enterprise (e.g., an original equipment manufacturer and its suppliers, or a consortium of public and private groups and academia), to be able to work from a common digital data base, in real time, on the design, development, manufacturing, distribution and servicing of products. The direct benefits would come through substantial reductions in product-to-market time and costs, along with significant enhancements in quality and performance.

B. STRATEGIC GOALS AND OBJECTIVES

The strategic plan is intended to expand upon the CALS Vision. Each of the three strategic goals and their supporting objectives is quoted below in italicized text and is elaborated upon in plain text.

1. Strategic Goal 1

Expand DoD's relationship with industry to adopt more harmonious methods of operation and data exchange. This goal describes the DoD's desire to work more closely with our nation's defense industrial base for weapon system procurements. In the past the DoD has relied heavily on military specifications and standards to direct contractors on how to deliver a product. With reduced levels of funding for defense acquisitions today, the DoD is seeking to substitute commercial equivalents for military needs whenever possible. This change places more trust on our defense industrial base to recommend industry standards in response to Requests For Comments (RFCs) and Requests For Proposals (RFPs).

a. Objective 1A

Develop a DoD and industry infostructure. Development of a common means of exchanging digital information between the DoD and industry is intended to integrate combat units with the defense industry. The architecture for this capability is being developed in concert with Command, Control, Communications, and Intelligence (C3I) planners within the Pentagon.

b. Objective 1B

Enable "dual use" technologies. "Dual use" technologies refer to industry or commercial products that fulfill military needs. The hope is that innovative commercial products will be delivered to combat forces more rapidly and at a lower cost to the DoD.

c. Objective 1C

Harmonize standards and practices. When the DoD feels the need to publish a military specification or standard, it currently submits it to industry groups and national and international standards organizations for comments. The goal is to have all possible military specifications and standards relating to information technology migrate to Federal Information Processing Standards (FIPS) or international standards in the future.

d. Objective 1D

Provide CALS expertise through education and training. The Defense CALS Executive is tasked to provide CALS implementation guidance for users and industry alike. Federal agencies such as the Department of Commerce (DoC) and the Advance Research Projects Agency (ARPA) are to assist the DoD in developing CALS curricula for entities such as small business defense contractors and academia.

2. Strategic Goal 2

Complete the transition of DoD's active information and business transactions to standard electronic formats. This goal describes the need for the DoD to abandon paper-based systems for technical documentation and logistics support in favor of digital data formats. Documentation required for the management of weapon systems acquisitions should be digitally encoded and simultaneously available to the DoD Program Executive Office and the defense primary and sub contractors.

a. Objective 2A

Modernize DoD hardware and software. This objective describes the transition from filing cabinets in DoD offices to computer workstations on every desk. As hardware and software is purchased for CALS-compliant purposes, adherence to open standards is mandatory.

b. Objective 2B

Acquire new data in digital form. Acquisition of new data in digital form requires the procuring military department or agency to have procedures in place for handling the digital data. Existing procedures for the handling of paper-based documentation will be insufficient for the manipulation and management of data in digital formats; these procedures must be reconsidered.

c. Objective 2C

Convert existing data to digital form. Paper-based legacy data must be evaluated for the cost effectiveness of its conversion to digital form. For weapon systems expected to remain in the inventory for years to come, conversion of their documentation

to digital formats must be done with an eye toward which digital formats are most widely accepted and most robust for future needs.

d. Objective 2D

Conduct business transactions in digital form. This objective is directed toward conducting defense acquisitions within the guidelines of Electronic Commerce (EC) using Electronic Data Interchange (EDI) standards. It is anticipated that this objective will lead to quicker turn-arounds on management decisions for acquisition managers.

3. Strategic Goal 3

Continue progress toward integration of DoD's digital information. This goal addresses the need for the DoD to be able to digitally share all information concerned with a weapon system with acquisition managers, contractors, logistics support personnel and end-users. The intent is to develop an Integrated Weapon System Data Base (IWSDB) as the repository for all data elements of a particular weapon system. Much fundamental research must be conducted to develop a data model, proper access restrictions and security protections for such a data base.

a. Objective 3A

Develop an integrated infostructure. This objective calls for the development of a standard for digital information exchange. Without efficient information sharing, management of business processes cannot effectively begin. The DoD is actively working with industry and national and international standards organizations to develop a digital information exchange standard that will adequately handle the requirements for a system that is expected to have a long life-cycle.

b. Objective 3B

Align defense integrated infostructure with the national information infrastructure. The National Information Infrastructure (NII) or "information superhighway" is in the conceptual stages with various federal agencies and the private

sector. The DoD must remain cognizant of the progress in defining the NII so that it may seamlessly integrate with it should the need arise in the future.

c. Objective 3C

Promote business process reengineering. Business Process Reengineering (BPR) was first introduced to the DoD in the Corporate Information Management (CIM) initiative in the late 1980's. As the DoD attempts to move away from managing paper-based systems to managing information digitally, it must avoid the urge to simply automate what perhaps is a bad process through the application of computer technology. Much effort must be conducted in the fields of workflow management, workgroup computing and business process reengineering to ensure that DoD agencies and military departments are prepared for the new ways of managing information.

C. CALS ORGANIZATIONS

This section describes the various government, industry and international organizations that participate in the CALS initiative.

1. Government

a. Department of Defense

Within the Department of Defense (DoD), the CALS initiative is managed by the CALS & EDI Office within the Office for the Under Secretary of Defense (Acquisition and Technology). This office is responsible for issuing CALS directives and coordinating CALS efforts among DoD military departments and agencies. The CALS & EDI Office is the point-of-contact for CALS issues when interacting with other federal agencies.

The Defense Information Systems Agency (DISA) Information Processing Directorate maintains the Center for Standards (CFS) as the DoD's repository for information processing standards. The CFS is authorized and responsible for adopting, developing, specifying, certifying and enforcing information processing standards for the DoD.

b. Department of the Navy

Each military department has a representative within the CALS and EDI Office and uses smaller entities to manage the CALS initiative. Within the Department of the Navy (DoN), the Naval Air Warfare Center, Naval Surface Warfare Center and Naval Undersea Warfare Center all have divisions that participate in the CALS initiative to varying degrees. The Carderock Division of the Naval Surface Warfare Center is the repository for CALS standards and the lead testbed for the CALS Test Network within the DoN.

The Naval Air Warfare Center, Aircraft Division, Indianapolis, IN and the Naval Surface Warfare Center, Crane Division, Louisville, KY and Crane, IN cooperatively maintain the CALS Resource and Implementation Cooperative (RIC). The RIC was established as the primary source for technical guidance for naval forces attempting to implement or apply the CALS initiative.

c. Federal Agencies

Besides the DoD, other federal agencies, such as the Department of Commerce (DoC) and the Advance Research Projects Agency (ARPA) have roles and responsibilities in the CALS initiative.

The National Institute of Standards and Technology (NIST), a part of the DoC, has been tasked to provide the DoD assistance in developing the CALS standards. NIST works with military departments and agencies, industry and national and international standards organizations to develop the CALS initiative standards and to make recommendations to the CALS and EDI Office on which standards to implement. Additionally, NIST through the Manufacturing Extension Partnership maintains thirty-six Manufacturing Extension Centers that help small-to-medium-sized manufacturers increase their international competitiveness. (Snodgrass, 1994, pg. 13)

The DoC's National Technical Information Service (NTIS) is the central repository for over 1,000 CALS documents. These documents are available through File Transfer Protocol (FTP) at Internet host address 192.239.92.203, by modem on FedWorld Bulletin Board System (BBS) at 1-703-321-8020 and voice telephone at 1-703-487-4823 (information) and 1-703-487-4650 (ordering).

ARPA manages the Electronic Commerce Resource Centers (ECRC) [1] which assist small manufacturers with CALS concepts and strategy by providing education and training. The ECRC will go as far as to visit manufacturers and conduct business-case analysis to determine return on investment on implementing CALS concepts. (Snodgrass, 1994, pg. 13)

2. Industry

The CALS initiative being a joint DoD-industry program, is primarily represented by the CALS Industry Steering Group (ISG). The CALS ISG leadership has recently renamed the CALS initiative to Commerce at Light Speed to better reflect the ISG's opinion that CALS strengths rest with Enterprise Integration (EI) efforts in manufacturing. (Snodgrass, 1994, pg. 11)

The CALS ISG has formed Regional Interest Groups (RIGs) to meet periodically with industry representatives to keep them current with the latest CALS developments. At the time of this writing there are CALS RIGs in at least 25 states. (Snodgrass, 1994, pg. 13)

For the purposes of providing individuals the opportunity to comment on CALS standards and specifications, the CALS ISG maintains a BBS. This BBS serves as a means for distributing of CALS documents and as a forum for submitting comments on proposed standards and specifications. The number for the BBS is 1-703-321-8020 for modem access. (Smith and Ellis, 1994, pg. 10)

3. International

At the seventh annual CALS conference and exposition on December 6, 1994, the CALS ISG Executive Advisory Council announced the formation of CALS International. CALS International will serve to advance international business by promoting the use of standards and shared digital data in electronic commerce. Presently, there are nine nations with CALS ISG organizations: United States, Canada, United Kingdom, France, Germany, Sweden, Japan, Taiwan, and Australia. Additional countries are expected to formalize a CALS organization with the announcement of CALS International.

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[1] These centers were formerly known as CALS Shared Resource Centers (CSRC).

The CALS International will consist of three elements:

- An International Board of Directors, responsible for setting priorities, defining long-range objectives and forging strategic partnerships and cooperative relationships;
- The International CALS Congress, responsible for developing a coordinated approach to implementing CALS requirements; and
- The International CALS Secretariat, responsible for providing staff support.

D. CALS DIRECTIVES, GUIDANCE AND STANDARDS

This section will describe the documentation associated with the CALS initiative.

1. Directives

Usage of CALS for the acquisition of new weapon systems and major equipment was first mandated in August 1988 by the Deputy Secretary of Defense in a memorandum to military department secretaries and the director of the Defense Logistics Agency. Citing that "CALS standards will enable either digital data delivery or government access to contractor-maintained technical data bases," CALS standards were specified for two types of acquisition scenarios:

- For systems now in full-scale development or production, program managers shall review specific opportunities for cost savings or quality improvements that could result from changing weapon system paper deliverables to digital delivery or access using the CALS standards.
- For systems entering development after September 1988, acquisition plans, solicitations, and related documents should require specific schedule and cost proposals for: (1) Integration of contractor technical information systems and processes; (2) Authorized government access to contractor data bases; (3) Delivery of technical information in digital form.

This memorandum (since canceled) was later codified in the Defense Federal Acquisition Regulation Supplement (DFARS). DFARS tasks acquisition managers and program offices for planned acquisitions to:

- Implement CALS standards in new defense system acquisitions with CALS requirements being incorporated in the Requests For Proposals (RFPs) and eventually the contracts;

- Describe the extent of how the CALS standards have been implemented in their acquisition planning;

- Ensure that their offices have the sufficient computer technology infrastructure in place and are capable of receiving and managing digital data.

For weapon systems already in the DoD inventory, DFARS requires managers to "exploit" the CALS standards by converting existing paper-based technical data to digital data. This requirement is made with the understanding that the program's phase, type, size and duration should be the overriding consideration before proceeding with any conversion.

Two other directives relating to the CALS initiative, both titled *Computer-aided Acquisition and Logistics Support*, include OPNAVINST 4120.5, dated 1 July 1992 and SECNAVINST 5000.2A, dated 9 December 1992 with Change 1 dated 26 February 1993. The Defense Acquisition Board, Logistics Review Groups, Major Automated Information System Review Council, and other unspecified oversight activities are tasked by the DFARS to review and audit defense acquisition managers for compliance with DoD and DoD component CALS policy.

On June 29, 1994, Secretary of Defense William J. Perry issued a memorandum to the Secretaries of the Military Departments and the Directors of the Defense Agencies directing that "performance specifications shall be used when purchasing new systems, major modifications, upgrades to current systems, and nondevelopmental and commercial items, for programs in any acquisition category. If it is not practicable to use a performance specification, a non-government standard shall be used." Secretary Perry allowed the use of military specifications and standards in cases where performance specifications or non-government standards are not cost effective. But a waiver for their uses must be granted by the Milestone Decision Authority (MDA) for the defense program. The memorandum went on to state that military specifications and standards listed in the DFARS, such as the CALS initiative's military specifications and standards, are no longer mandatory and should be viewed as only guidance by program managers. (DoD OSD, 1994, pg. 2)

2. Guidance

This section will describe the two guides applicable to Department of the Navy acquisition managers. Both are available in digital form from the NTIS.

a. DoD CALS Implementation Guide

The DoD Implementation Guide for CALS is a Military Handbook (MIL-HDBK-59B) prepared by the DoD CALS & EDI Office with the assistance of the military departments, federal agencies and the defense industry. Applicable to all the military departments and DoD Agencies, this handbook addresses:

- CALS strategy;
- DoD CALS policy;
- Acquisition process guidance;
- Special considerations for existing defense systems;
- Infrastructure modernization.

b. Navy/Marine Corps Manager's Desktop Guide for CALS Implementation

This guide in its third edition dated 30 September 1994, is produced by the Navy CALS Resource and Implementation Cooperative (RIC) at the Naval Air Warfare Center, Aircraft Division, Indianapolis. At over 450 pages in length, it provides invaluable guidance for DoN activities seeking information about the CALS initiative and its standards and specifications.

3. CALS Standards and Standardization Documents

To achieve the goal of digital data interchange, definition of data standards is considered a necessity. The CALS policy is to adopt private sector (i.e., non-government) data standards, which are anticipated to have long life-spans. The definition of the data storage and retrieval system, which is anticipated to have a shorter life-span, is left to users. This section discusses the differences between a CALS Standard and a CALS Standardization Document. It concludes with a discussion of the standardization process.

a. CALS Standards

A CALS Standard is considered to be a non-government data standard that is approved by a standards-setting organization such as the American National Standards Institute (ANSI) or the International Standards Organization (ISO). These standards are intended to function at the Presentation Layer and Application Layer of the Open Systems Interconnection (OSI) Reference Model. Examples of CALS Standards include:

- ANSI Y14.26M, Initial Graphics Exchange Specification (IGES);
- ANSI X3.122, Computer Graphics Metafile (CGM);
- ISO 8879, Standard Generalized Markup Language (SGML).

b. CALS Standardization Documents

CALS Standardization Documents are the DoD interpretations and implementations of a non-government data standard. Examples of CALS Standardization Documents include:

- MIL-D-28000, Digital Representation for Communication of Product Data: IGES Application Subsets;
- MIL-D-28001, Markup Requirements and Generic Style Specification for Electronic Printed Output and Exchange of Text;
- MIL-R-28002, Requirements for Raster Graphics Representation in Binary Format;
- MIL-D-28003, Digital Representation for Communication of Illustration Data: CGM Application Profile.

These Standardization Documents will be explained in greater detail in the next chapter, "CALS Data Format Specifications."

c. Standardization Process

The practice of the DoD to use a non-government standard in the CALS initiative stems from the desire to reap the benefits of using recognized standards with an installed base of users. The hope is this criterion will ensure a wide choice of

implementation tools and the resultant reduction in procurement and life-cycle costs for a system.

The DoD chooses CALS standards from the following organizations that are listed in decreasing order of preference:

- International standards body such as the International Standards Organization (ISO);
- National standards body such as the American National Standards Institute (ANSI);
- Industry professional society such as the Institute of Electrical and Electronic Engineers (IEEE);
- A de-facto industry standard if no other choice is available.

The DoD and the defense industry have agreed upon a six-step process to select and implement a standard for the CALS initiative. In practice for over three years, these steps are listed below (Smith and Ellis, 1994):

1. Identify the standardization requirement;
2. Initiate a standardization project;
3. Develop the necessary standardization document;
4. Coordinate the draft standardization document;
5. Resolve any comments generated by the coordination review; and
6. Publish the approved standardization document.

E. IMPLEMENTATION OF THE CALS STRATEGY

The Department of Defense's goal for the CALS strategy, as described in MIL-HDBK-59B, is transition of weapon system acquisitions from a paper-based system to one where all technical data is in digital formats and managed automatically. The envisioned implementation of this goal is the Integrated Weapon Systems Data Base (IWSDB). In the IWSDB all technical data related to a weapon system is logically stored in one data base. This logical data base is accessible to the DoD acquisition managers, contractors

and their sub contractors, DoD logistics support activities, and the end users. (DoD CALS Office, 1994, pg. 4)

The remainder of this section describes the four target areas in a weapon systems life-cycle that need to be addressed for implementation of the CALS strategies and objectives. This section concludes by presenting acquisition process guidance for weapon system acquisition managers who intend to implement CALS strategies and objectives.

1. Target Areas for Implementation of the CALS Strategy

This section presents the four areas during a typical weapon system's life-cycle that require attention when attempting to implement the CALS strategy.

a. Infrastructure Modernization

Infrastructure modernization refers to removing filing cabinets, typewriters, printing presses, copier machines and replacing them with computer and telecommunications technology. This strategy must be pursued within the requirements of existing Federal Information Processing Systems (FIPS) guidance and should follow an open-system, scaleable, standards-based architecture. This strategy is being achieved by two methods:

1. Development of a Joint Service system that has the target architecture; and
2. Migration of existing systems to the CALS requirements through modification and upgrades.

b. Process Improvement

Process improvement indicates the need for examination of current practices with paper-based acquisition procedures and evaluating whether the procedures are still valid in an automated acquisition environment with digital data. Reengineering and business process improvement are some of the techniques that will need to be used to avoid the temptation of simply automating what may be a faulty process.

c. Digital Data Acquisition

Acquisition of digital data is the bold step of accepting technical documentation of a weapon system in digital formats rather than in "camera-ready copy"

or "final reproducible copy" formats. Interchange and exchange of digital data over a variety of computer systems will require standardization of digital data formats and data interchange procedures.

d. Integration

This fourth target area for implementation is the definition of a logical data structure for all weapon system information. This will ensure all related data will be maintained in a common data base, such as the IWSDB concept, over the life-cycle of that weapon system. (DoD MIL-HDBK-59B, 1994, pp. 4-5)

2. Acquisition Process Guidance

This section describes how the CALS strategies and objectives are implemented in the acquisition of a typical defense system.

a. Acquisition Planning Process

The Defense Federal Acquisition Regulation Supplement (DFARS) Part 207.105 requires the acquisition plan for a weapon system to include a description of how the CALS initiative has been incorporated in life-cycle cost considerations. The acquisition plan should include the program's strategy for acquiring and managing the technical data associated with a weapon system in digital formats. Since each weapon system procurement has unique technical data and information requirements, the program office in their strategy for digital data acquisition and management, should address the following issues: infrastructure, data access, data management, data flow, and data exchange. (DoD CALS Office, 1994, pg. 9)

The CALS Government Concept of Operations (GCO) is a document prepared by the weapon system program office during the acquisition planning process. It describes to potential offerors what the infrastucture and CALS implementation strategy will be for the particular weapon system program. The GCO is usually prepared once the program office has received inputs from all the defense activities expected to support the weapon system during its life-cycle. It is included as Government Furnished Information (GFI) within the Request For Proposal (RFP).

Specific guidance for developing a GCO and a sample questionnaire is contained in MIL-HDBK-59B, Annexes E and F. The major points of a GCO may include:

- Identification of data type deliverables;
- Identification of data users;
- Identification of data use and processing;
- Identification of data user infrastructure;
- Identification of data delivery and type;
- Identification of data format;
- Identification of data interchange standards; and
- Determination of mechanism and types of media for data delivery and access.

b. Solicitation and Selection Process

Completion of the acquisition process planning stage and formulation of a CALS Government Concept of Operations firmly grounds the weapon system acquisition management team in the CALS principals as it enters the solicitation and source selection process. During the solicitation and selection process, the most critical element is for acquisition managers to communicate their CALS implementation strategy in the RFP. MIL-HDBK-59B contains explicit examples of how CALS language may be incorporated in an RFP in order that the potential offerors understand exactly how CALS principals will be implemented in this particular weapon system program.

Section L of a RFP contains the Instructions to Offerors (ITO). This section is used to instruct potential bidders to submit a Contractors Approach to CALS (CAC). The CAC is a comprehensive document detailing the contractor's "approach, experiences, and successes in the creation, management, use, and exchange of digital information" (DoD CALS Office, 1994, pg. 22). This document can be useful to the program office in evaluating the contractor's capabilities to create and manage digital data as specified in the RFP. This section may also be used to solicit alternative proposals from potential contractors such as alternate delivery methods of data requirements specified in

the RFP. These alternate proposals should be aimed at reducing life-cycle costs for the weapon system and thus must be submitted with supporting cost and benefit justification information. (DoD CALS Office, 1994, pg. 23)

c. Implementation Process

The implementation process for the CALS strategy involves a three-part approach: on-line services; digital data delivery; and integration of product, process, and data. The implementation process encompasses the input of specified data elements from a weapon system contract. The data elements are developed using CALS military standards; data format specifications; and product, process and data integration standards. These are provided in a CALS/Concurrent Engineering environment to yield CALS digital data products useful for the weapon system's life-cycle. (DoD CALS Office, 1994, pg. 24)

F. CALS INFRASTRUCTURE MODERNIZATION SYSTEMS

This section describes the two "flagship" CALS systems: Joint Computer-aided Acquisition and Logistics Support (JCALS) and the Joint Engineering Data Management Information and Control System (JEDMICS).

1. Joint Computer-aided Acquisition and Logistics Support

The CALS implementation target area, infrastructure modernization, has been realized in the Joint Computer-aided Acquisition and Logistics Support (JCALS)[2] Program. The JCALS concept originated from the US Army's Technical Information Management System (TIMS), which became the Army CALS (ACALS) program in March 1987. In January 1991, the Army was directed to transition ACALS, already in Phase I of its development by Computer Sciences Corporation (CSC) of Moorestown, NJ, to include joint requirements and to make it a joint program. The Joint CALS concept was demonstrated by two contractors in February 1991 and was designated a joint service program in October 1991. CSC was awarded the JCALS contract, valued at $ 744 million

[2] Although the DoD has changed the CALS to Continuous Acquisition and Life-Cycle Support, the JCALS Program Office has retained the older meaning for CALS, Computer-aided Acquisition and Logistics Support.

if all options are exercised, in December 1991 (Zurier, 1993, pg. S4). The program is currently in Phase III. The remainder of this section describes the JCALS system design, implementation, components, and future developments.

a. System Design

JCALS is an information management system that will support acquisition, logistics support, engineering, manufacturing, configuration control and materiel management processes throughout the life-cycle of a weapon system. It uses multi-weapon system IWSDBs and Global Data Dictionary and Directory (GDD/D) Services that are connected by a wide area computer network. The interface for users is the JCALS Workbench that provides an environment to access all of JCAL's functionality transparently to the user. JCALS was designed within the CALS requirements and CIM Technical Reference Model (TRM) architecture. It uses open systems standards, making it flexible and scaleable. (DoD MIL-HDBK-59B, 1994, pg. 34)

The design specifications for JCALS indicate that it can have a bi-directional interface with Contractor Integrated Technical Information Services (CITIS) and Electronic Data Interchange (EDI) suppliers over a Wide Area Network (WAN). CITIS is an information system furnished by a defense contractor that provides access to the technical data and information associated with a defense system contract to government acquisition managers and technical representatives. This bi-directional interface can be one or more of the four types listed below (DoD MIL-HDBK-59B, 1994, 37):

1. non-interactive data exchange using removable digital media;
2. selected CITIS functions using dial-up or network access capabilities;
3. on-line interface where data dictionaries are mapped to each other for transparent, seamless access; and
4. fully integrated, JCALS site-type interface for which the contractor is furnished GDD/D services, software and if required, equipment.

b. System Deployment

Presently JCALS is in prototype at six DoD sites: Marine Corps Logistics Base Albany, GA; Marine Corps Base Quantico, VA; Tinker Air Force Base (AFB), OK; Warner-Robbins AFB, GA; Naval Surface Warfare Center (NSWC), Port Hueneme, CA; and the Army's Missile Command in Huntsville, AL.

JCALS also has four Technology Application Sites currently located at: Los Angeles AFB, Los Angeles, CA; Peterson AFB, Colorado Springs, CO; McClellan AFB, Sacramento, CA; and NSWC, Dahlgren, VA. If fully deployed, JCALS will eventually have 245 sites connected over the Defense Information Systems Network. Delivery of the first JCALS system is expected to begin in the first half of 1996.

c. System Configuration

The JCALS software is a suite of commercial off-the-shelf software (COTS) and Government Owned Software (GOTS) that are integrated by CSC with custom Ada code. Current COTS packages include: Oracle Corporation's Trusted Oracle 7 database management system, Digital Equipment Corporation's (DEC) Multilevel Secure Plus Operating System, ArborText Incorporated's AdeptPublisher, and numerous utility and viewer applications. CSC states that COTS (which are designed into the X-Windows operating system to provide consistent user interfaces) currently make up about 95 percent of the JCALS software suite (Endoso, 1994, pg. 39).

The GOTS portions of JCALS include a Workflow Manager application created in the Ada programming language, the Global Data Base Manager (GDMS), and the Reference Library. The workflow manager application provides a user tool for analysis using the principals of Business Process Reengineering involving digital data. A completed workflow will contain all the database links necessary between the individuals and technical data associated with a particular process. The Reference Library is a repository for publications, documents, engineering drawings and illustrations that are accessible to JCALS users through the Reference Library Search tool. Depending on an individual's access rights, a user may either view or review and annotate any document contained in the Reference Library.

A typical JCALS site will have a Fiber-optic Distributed Data Interface (FDDI) backbone ring with the JCALS engine consisting of the GDMS, Network

Processor and Internet Protocol Router. The JCALS work group consists of DEC Alpha workstation servers, X-terminal workstations, and various other peripheral devices. This hardware is interconnected by Ethernet cabling. Figure 1 depicts a typical JCALS system configuration.

Presently, the only application developed by CSC that is operational on the JCALS infrastructure is the Technical Manual Management System (TMMS). This system permits users to acquire, manage, and author technical manuals including the production of reproducible copies, in either digital or paper formats. The TMMS system integrates the common user interface (workfolder concept), workflow management application, and the GDMS access to technical data. (Gourley, 1995, pp. 20-21)

d. Recent Developments and Future Enhancements

Through each software upgrade to JCALS, performance enhancements and improved capabilities have been added to the different software modules. In JCALS' most recent software upgrades, a PC client application and a basic interface to JEDMICS, and several other DoD information systems were added. Future JCALS enhancements will include integration of COTS applications (such as Adobe Systems Acrobat Press and Reader) and providing multimedia capabilities for the authoring and creation of Interactive Electronic Technical Manuals (IETMs).

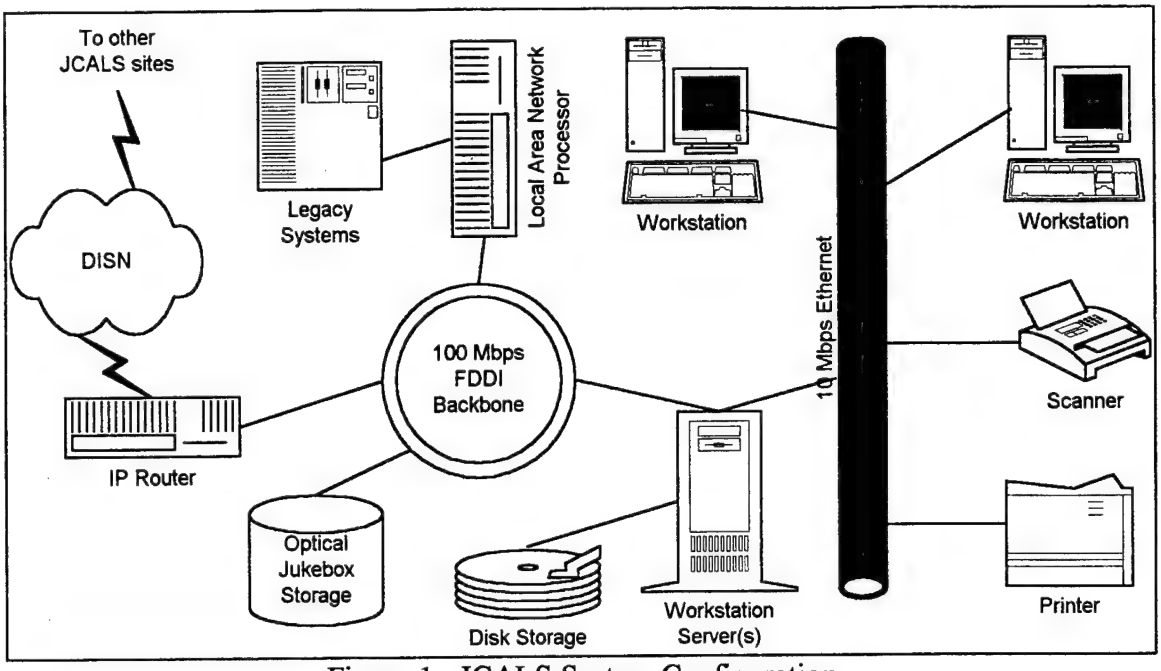

Figure 1. JCALS System Configuration

2. Joint Engineering Data Management Information and Control System

The Joint Engineering Data Management Information and Control System (JEDMICS) is a CALS-compliant repository for the storage of engineering drawings and related technical data. It originates from the Engineering Data Management Information and Control System (EDMICS). EDMICS was a Navy program with a ten year firm-fixed price indefinite-delivery, indefinite-quantity contract. It had been awarded to PRC, Inc. of Reston, VA in 1989. The EDMICS program was validated as a program meeting the CALS initiative strategies and objectives in 1991 and selected as a tri-service program later that year. In 1993 EDMICS was chartered as a joint program by DoD and renamed JEDMICS. The Navy retained management responsibilities for the program.

a. System Design

JEDMICS consists of six subsystems that permit users on-line access to engineering drawings and related technical data stored in CALS data formats. The six subsystems (input, data integrity, index, storage, output, and remote output) follow a standard open system design in a client-server architecture. The subsystems are scaleable and compatible with existing applications and information systems at a particular

JEDMICS site. JEDMICS supports the input and output of paper drawings, text pages, aperture cards, Computer-aided Design (CAD) files, magnetic tapes, optical players, and direct connections to and from other information systems. It maintains the drawings and technical data in the following CALS file formats: Raster, ASCII, binary, 2D/3D vector, SGML, IGES, and CGM.

b. System Deployment

Presently there are twenty-four JEDMICS sites installed at Navy, Army, Air Force, and Defense Logistics Agency sites. A typical JEDMICS site will include maintenance and logistics activities such as Naval shipyards, the Marine Corps logistics bases, Army depots, Air Force depots and Defense supply centers that require access to engineering drawings.

c. System Configuration

JEDMICS consists of GOTS and COTS software that are integrated through a JEDMICS Application Program Interface (API) that permits the software to operate in a C-2 level secure, client-server environment. The custom GOTS applications provide for indexing, retrieval, security, backup, archiving, import/export, and management reporting. The COTS applications include the Oracle database management system, UNIX operating system and various utility applications for viewing and converting the variety of data file formats.

Current server platforms include Digital Equipment Corporation (DEC) VAX/VMS mainframe computers, Silicon Graphics and Hewlett Packard workstations. Client platforms include workstations and microcomputers from DEC, Sun Microsystems, Intergraph, Silicon Graphics, and numerous desktop microcomputers running various operating systems and application programs. JEDMICS uses Kodak optical jukeboxes as the storage device for engineering drawings and technical data.

d. Recent Developments and Future Enhancements

The JEDMICS API developed in 1994 permits JEDMICS to operate with other information systems in Local Area and Wide Area Network environments. In October 1994 the interface between JEDMICS and JCALS was demonstrated when a user

on a JCALS workstation was able to query and retrieve engineering drawings from a JEDMICS repository.

As the military services digitize their technical data in CALS data formats, JEDMICS hopes to become the standard repository for all technical data, including technical manuals. Continued improvements to JEDMICS' interface and access methods, will allow DoD and private sector engineering, planning, logistics, training, and maintenance organizations to share the same technical data throughout the life-cycle of a defense system.

III. CALS DATA FORMAT SPECIFICATIONS

This chapter presents the CALS specifications and standards related to the publishing of technical data. The word "publishing" means to prepare and issue (the assumption is printed material) for public distribution or sale. Under the CALS initiative, the specifications and standards relating to the production of technical data has automated the exchange of illustrations, drawings, text, images, and graphics used in technical documentation. This chapter describes four of the most significant military specifications and standards relating to producing technical data and publishing technical manuals. These specifications are known as the CALS Data Format Specifications and are commonly referred to as the "28000 series specs,"

A. MIL-D-28000A

The MIL-D-28000A military specification is an example of a CALS standardization document that provides implementation guidance for an industry standard. It addresses the digital representation of product definition data using a subset of the Initial Graphics Exchange Specification (IGES) as defined by the American Society of Mechanical Engineers standard Y14.26M (Digital Representation for Communication of Product Definition Data). MIL-D-28000A's full title is "Digital Representation for Communication of Product Data: IGES Application Subsets and IGES Application Protocols."

1. Purpose and Applicability

This standard relates to the interchange of Computer Aided Design (CAD) system generated drawings between two applications from two different software vendors. This section describes how MIL-D-28000A provides for this interchange through the definition of Classes, Application Subsets, and Application Protocols.

a. Classes and Application Subsets

MIL-D-28000A specifies only five of all the possible classes within the IGES standard. These classes are:

- Class I, Technical Illustrations Subset;
- Class II, Engineering Drawings Subset;
- Class III, Electrical/Electronic Applications Subset;
- Class IV, Geometry for Numeric Control Manufacturing Subset; and
- Class V, 3D Piping Application Subset.

The IGES standard is considered to be a voluminous standard with the flexibility of allowing a variety of ways to represent the same Computer Aided Design (CAD) model entity. CAD vendors usually only provide a subset of the IGES standard for use in their CAD applications. When entities are exchanged between different CAD applications, mismatches inevitably occur between IGES entities in use by the two CAD systems.

The first four of the classes listed above explicitly specify the entities required for their Application Subsets. A provision in the standard is made for a "volunteer entity" for the purpose of recreating the environment of the transmitting CAD system on the receiving CAD system. (Garner, et. al., 1994, pg. 3-2)

b. Application Protocols

When interchanging product data using the IGES standard, the Application Protocol (AP) defines the user requirements for the applications based on the Application Reference Model. The AP is specific for a particular class of drawings and provides the means for how information is mapped into the required IGES entities.

c. Vendor Support

Most CAD application software vendors today provide some level of IGES compatibility with a translating routine. Vendor support for MIL-D-28000A is not as prevalent as for the full IGES standard, though some of the classes are supported more than others. Currently Class II, engineering drawings, and Class I, technical drawings, are the two most supported classes within MIL-D-28000A. There is at least one non-CAD software application, the Interleaf document publishing system, that provides support for

both the IGES standard and Classes I and II of MIL-D-28000A. (Garner, et. al., 1994, pg. 3-7)

2. Future of Standard

This standard is dependent on the IGES standard version 5.1 and the American National Standard Y14.26M of 1989. The CALS Evaluation & Integration Office works closely with the standards organizations through the organization's CALS/IGES Special Interest Group. This group actively reviews proposed changes and makes inputs on how the standard can be improved through revisions. (Garner, et. al., 1994, pg. 3-5)

B. MIL-M-28001B

This military specification was one of the most controversial parts of the CALS initiative when it was first issued in 1988. As a standardization document now in its second revision, it is intended to provide implementation guidance for the international standard ISO 8879, "Standard Generalized Markup Language (SGML)." This military specification today, has become widely accepted by software vendors and national and international defense industries.

1. Purpose and Applicability

MIL-M-28001B, "Markup Requirements and Generic Style Specification for Electronic Printed Output and Exchange of Text," sets out the requirements for the delivery of page-oriented technical documentation in digital form. This specification's intent is to ensure that documents, prepared with authoring tools compliant with the ISO standard, may be automatically stored, retrieved, interchanged and processed among differing computer hardware and software systems at government and contractor sites.

The specification details the procedures and symbology for the markup of unformatted text using the SGML standard for the purposes of encoding and formatting technical publications using Document Type Definitions (DTDs). Further, the specification sets out the requirements for how technical documentation, encoded in SGML, can be printed in a format compatible with the existing military specification for technical manuals and technical publications, MIL-M-38784C. This output of SGML encoded text is accomplished by the creation of a Formatting Output Specification

Instance (FOSI) based on MIL-M-28001B's Output Specification (OS). Specific details about DTDs, OS, and FOSI are presented in the section title "SGML Constructs and the Document Style Semantics and Specification Language" that follows.

Appendix C of MIL-M-28001B provides information on how a review and comment capability can be incorporated into a SGML publishing environment. This capability is invaluable when documents in preliminary form must be sent by the contractor to the government for review before they can be issued in final form. (Garner, et. al., 1994, pg. 4-6)

a. Advantages

The chief advantage of this specification is its ratification of SGML as a means for the interchange of ASCII text data. With ISO 8879 being an international standard, it makes document production and management easier by offering a method of authoring, storing and managing documents without the constraints of proprietary computer hardware configurations and software applications.

b. Military Handbook SGML

Military Handbook SGML (MIL-HDBK-SGML) offers additional guidance for application of MIL-M-28001B and ISO 8879. Issued by the DoD CALS and EDI Office, it is currently in draft form dated 21 June 1993. It is expected to be issued in final form in 1995 and will be available from the NTIS in digital formats. The substantive portion of the handbook provides an overview of SGML from the perspective of how it fits within the CALS strategy and then provide sections that describe the following tasks for an SGML user:

- Performing a document analysis
- Developing a DTD based on a document analysis
- Tagging textual information based on a DTD
- Preparing a FOSI in accordance with the OS in MIL-M-28001B
- Using the SGML Reuse Library and SGML Tagset Registry. (MIL-HDBK-SGML, 1993, pg. 1)

The SGML Reuse Library and SGML Tagset Registry have been created by the Electronic Publishing Committee of the CALS ISG to serve as the repository for SGML constructs used in CALS applications. The Reuse Library maintains SGML constructs such as DTDs (and fragments thereof) and FOSIs while the Tagset Registry maintains constructs such as elements, attributes, and entities. (MIL-HDBK-SGML, 1993, pg. 86) The Navy has developed a Navy Baseline Tagset that includes tags for use with the technical manual specification MIL-M-38784C to minimize the proliferation of differing tags and duplicate definitions for tags.

c. Vendor Support

Numerous products that support SGML publishing requirements currently exist in mainframe, UNIX and Microsoft DOS/Windows operating environments. SGML applications to visualize the hierarchical nature of DTDs, create new DTDs, and convert WordPerfect and Microsoft Word document styles to DTDs have been in existence since 1993. Complete SGML authoring environments allow the user to accomplish SGML publishing with varying degrees of ease of use. Public domain SGML parsers, and DTD creation software applications for the DOS operating system, are in existence and are useful for academic purposes and smaller SGML implementations.

SGML publishing software vendors have implemented the ISO 8879 SGML standard to their products with minor variations. These differences with the SGML parser result in DTDs and FOSIs created by one vendor's application not successfully parsing or displaying in another vendor's application. While these differences are minor in most cases, they only add to the frustration of users when two applications that claim compliance with an international standard are not seamlessly compatible with each other.

Vendors have been careful not to tie their product too closely to this still evolving military specification, lest the alienation of the civilian commercial market. Some of the most significant SGML implementations have occurred in the aviation, automotive and heavy equipment industries. Nearly all the major software vendors participate in the Electronic Publishing Committee of the CALS Industry Standards Working Group, which is the primary organization responsible for the development of MIL-M-28001. This committee reviews comments on proposed amendments and future revisions of the

standard that are generated by government and industry users of the standard. (Garner, et. al., 1994, pg. 4-9)

2. SGML Constructs and the Document Style Semantics and Specification Language

This section describes two SGML constructs in greater detail and includes an example of a Document Type Definition and an example of a Formatting Output Specification Instance. This section concludes with a description of the Document Style Semantics and Specification Language and its future impact on publishing with SGML.

a. Document Type Definition

A document type definition is a SGML file that details the structure of the information for a particular document. Its creation is usually the result of a group effort among individuals having adequate working knowledge of SGML and familiarity with a certain type of document, a technical manual for instance. The group begins document analysis by ignoring the formatting characteristics of the document and only studying how information within the document is structured. Only then will the group be able to begin to create a DTD.

The DTD is an ASCII text file that contains the declarations, or elements, that describe how the information within a document is structured. The DTD is written using SGML syntax and formatting and must be parsed by a ISO 8879 compatible validating parser[3] before it may be used. Each of these elements will become tags in the SGML instance file indicating the start and finish of a particular segment of information within the document. The elements in the DTD may also have attributes associated with them. These optional attributes provide a means to detail the possible values, including a default value, for an element. Figure 2 (top) shows a DTD for an office memorandum. The actual memorandum, as an SGML document instance, is shown in Figure 2 (bottom). In summary, the DTD defines what type of document is being modeled, which elements are permitted, how the elements are sequenced, and what attributes are possible for each element.

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[3] A validating parser is a program that reads a DTD and checks whether errors are present and provides a report if they are. (van Herwijnen, 1994, pg. 278)

b. Output Specification

The purpose of the Output Specification (OS) is to provide a means to exchange the style and formatting information among SGML publishing systems. The OS

```
<!--    Lines that start and end with two dashes are comments.                -->
<!--    This is a DTD for an office memorandum                                -->
<!ENTITY  % doctype "MEMO"                                                    >
<!--            ELEMENTS        MIN     CONTENT                               -->
<!ELEMENT       %doctype;       - -     ((TO & FROM), SUBJ, BODY, CLOSE)      >
<!ELEMENT       TO              - O     (#PCDATA                              >
<!ELEMENT       FROM            - O     (#PCDATA)                             >
<!ELEMENT       SUBJ            - O     (#PCDATA)                             >
<!ELEMENT       BODY            - -     (PARA)*                               >
<!ELEMENT       PARA            - O     (#PCDATA | LIST)*                     >
<!ELEMENT       LIST            - -     (#PCDATA)                             >
<!ELEMENT       CLOSE           - -     (#PCDATA)                             >
```

```
<MEMO>
<TO>Robert Smith
<FROM>John Jones
<SUBJ>Company Picnic
<BODY>
<PARA>Here are my ideas for activities at Saturday's picnic:
<LIST>Volleyball, Softball, Horseshoes, Square Dancing.</LIST>
<PARA>Let me know what you think?
</BODY>
<CLOSE>Regards, John</CLOSE>
</MEMO>
```

Figure 2. Document Type Definition and Corresponding SGML Document Instance

document type definition describes how the Formatting Output Specification Instance (FOSI) should be created for documents that have their source data tagged according to a DTD.

The FOSI specifies the layout, formatting, and styles for the displaying of SGML encoded documents in a page-oriented format using the publishing software that the FOSI was created on. A FOSI is written for a particular class of documents that will be outputted in a particular format. For example, a FOSI created for use with technical manuals would be designed to conform with the format specified in MIL-M-38784C. It selectively takes any of the possible formatting and style characteristics from the OS DTD and details how they are to be used for outputting a page of a technical manual. It is important to note that because FOSIs specify formatting information, they are necessarily

proprietary to the SGML publishing application or FOSI composition tool that was used to create the FOSI.

c. Document Style Semantics and Specification Language

A major shortcoming of the SGML standard is the lack of a definite method of formatting SGML encoded information. Consequently, software vendors have created and implemented FOSIs, an extension of SGML, to specify how SGML encoded information can be outputted in a particular format or style using their SGML publishing application. The DoD, with MIL-M-28001B and the OS, followed a similar route. It specified to developers how to use the OS to create FOSIs to output printed technical manuals, according to the technical manual specification. Formatting instructions in any form for use with a publishing application are necessarily proprietary. FOSIs are considered a necessity until a better method could be developed.

The Document Style Semantics and Specification Language (DSSSL) is a language that allows the user to define how processing information, or formatting, should be associated with a SGML document. DSSSL is not SGML, but a query language that allows the user to identify SGML elements from the SGML document instance. Then the user may attach semantics such as formatting, style, and layout information to the elements from the DSSSL document architecture (van Herwijnen, 1994, pg. 226). Presently nearing ratification as an international standard, DSSSL permits the specification of formatting, style, and layout information without having ties to a particular publishing application.

3. Future of Standard

This standard has oscillated from being too specific and directive in nature to being too general. Revision A of this standard contained a DTD modeled after the technical manual specification at the time MIL-M-38784B. It also contained twelve derivative DTDs based on the master DTD. The current version of this standard, revision B, contains only a sample DTD "template" that is intended to be a "toolkit" for DTD developers. If this DTD is taken literally, it will not yield a parseable SGML instance. (Garner, et. al., 1994, pg. 4-1) Presently, the Computer Sciences Corporation (CSC) under the JCALS contract is designing a MIL-M-38784C conforming DTD titled the

"Quest-DTD" in the JCALS SGML authoring tool, ArborText Incorporated's AdeptPublisher.

Amendment 1 to MIL-M-28001B is expected to be made public in early 1995 and will primarily contain changes to the OS contained in Appendix B. Future revisions of this standard should distance themselves from a specific class of documents and focus on DoD-specific implementation issues with the international SGML standard. Guidance concerning specific DTDs should be appended with the military specification that covers that particular class of documents or incorporated within MIL-HDBK-SGML. For instance, the DTD and FOSI for technical manuals should be contained in an appendix to MIL-M-37874C. Plans for issuing Revision C of MIL-M-28001B are underway, with its release expected in 1996 or possibly 1997.

C. MIL-R-28002B

This military specification was originally conceived because of an absence of national and international standards for the storage and exchange of large engineering drawings as raster graphics files. Now known as a standardization document, its current version is based on ISO standards and the Committee on Telegraph and Telephone (CCITT) recommendations.

1. Purpose and Applicability

This specification details how a contractor should deliver raster data to the government. It establishes the requirements for a standard interchange file format and the raster encoding scheme for raster data. Raster data or graphics are the digital representations of an image using picture elements. Picture elements have the information, such as lightness, darkness, gray-level and color, for a particular portion of the image they represent. The density of picture elements will determine how good the resolution of the image will be in raster data format and how large the raster data file will be for storage. (Garner, et. al., 1994, pg. 5-1)

MIL-R-28002B identifies two types of digital representations, or file formats, of raster data designated Type I and Type II. Type I raster files, also known as untiled raster files, are the result of digitizing an image to a single bitmap and then compressing it into a single file. Type II file format corresponds to the Open Document Architecture (ODA)

document as specified by ISO 8613, "Information Processing - Text and Office Systems - Open Document Architecture" standard. A Type II representation may consist either untiled raster data with the ODA parameters and data structuring or tiled raster data. Subdivision of an image into to non-overlapping segments, or tiles, yields tiled raster data. Each of the tiles is then handled as a separate picture element array. Tiled raster data is most often used in large mechanical drawings where there are large areas of open space. The compression standard specified by MIL-R-28002B for these types of file formats is Group 4 encoding as defined by the CCITT Recommendation T.6, "Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus."

a. Advantages

The prime advantage of MIL-R-28002B is its commitment to follow developments with international standards and trends in industry. Whereas the origins of this standard were to fill a void for requirements for handling large engineering drawings, the CALS Policy Office has resolved to work side-by-side with industry by forming a joint Industry/DoD Tiling Task Group. The Tiling Task Group is headed by NIST and continues to monitor and develop issues related to MIL-R-28002B. (Garner, et. al., 1994, pg. 5-5)

b. Current Implementations

This standardization document is used in several DoD programs. The Navy Automated Document Management And Publishing System (ADMAPS) uses the specification for document scanning, raster image display and raster image storage. The Air Force Engineering Data Computer-Assisted Retrieval System (EDCARS) and the Army Digital Storage and Retrieval Engineering Data System (DSREDS) have used the MIL--R-28002A standard for Type I raster graphics files. These raster graphics files have been successfully interchanged using MIL-D-1840A and displayed on the Engineering Data Management Information Control System (EDMICS), now known as Joint EDMICS (JEDMICS). (Garner, et. al., 1994, pp. 5-2, 5-7)

c. Vendor Support

Presently, InterLinear Technology's Modular Electronic Document Information Solution is the only software application that supports both MIL-M-28002B Type I and II raster graphics files (Garner, et. al., 1994, pg. 5-8).

2. Future of Standard

This standard is in its third revision and has been revised every two years since originally issued in 1988. It is anticipated that future revisions will follow international standards developments and industry trends. The portions of this standard relating to the Group 4 encoding compression and the ODA Raster Document Application Profile will be removed once they are incorporated by NIST into FIPS publications.

D. MIL-D-28003A

This standardization document was developed for the DoD by NIST in coordination with several industry groups. Titled, "Digital Representation for Communication of Illustration Data: Computer Graphics Metafile (CGM)," this standard is used when graphics or illustrations are interchanged between two systems in binary form.

1. Purpose and Applicability

The CGM standard is published by the ISO (ISO/IEC 8632), the ANSI (ANSI/ISO 8632.1-4:1992), and the federal government (FIPS PUB 128) and defines the lowest level of drawing functionality required to reproduce a picture with a drawing application. Being a standard, CGM is defined to be independent of specific hardware platforms and software applications. A metafile is created by a drawing application generator and contains the information required for the picture data for the file. If the file is imported into a second drawing application an interpreter reads the information so that it may work with the file. To accommodate a variety of existing drawing applications, the CGM standard intentionally only specifies the output primitives and attributes and does not specify the semantics for picture data. This creates the requirement for an Application Profile. (Garner, et. al., 1994, pg. 6-1)

With MIL-D-28003A, the DoD has defined how CGM files should be used with CALS applications. The Application Profile defines rules for the generator and interpreter for a drawing application that seeks compatibility with the CALS initiative. Although illustration data files can be interchanged in text, character and binary formats, this standard only approves the use of binary format for the encoding of CGM files. (Garner, et. al., 1994, pg. 6-2)

a. Advantages

The primary advantage of this standard is its independence from particular hardware platforms such as monitors, printers, plotters, cameras, and software applications such as drawing and publishing applications. CGM is considered to be the best format for illustration data when compared to raster (larger size and dependence on the resolution of the output device) and 2D IGES (larger size and slower speed). (Garner, et. al., 1994, pg. 6-6)

b. Vendor Support

This standard with its Application Profile is considered a subset of the international and national CGM standard. Many vendors that claim CGM standard conformance, do not conform with MIL-D-28003A because of the lack of the Application Profile details necessary for use with CALS applications. Currently six software vendors (Ashton-Tate, Computer Support, Lotus Development, Micrografx, Hewlett-Packard, and Software Publishing) offer applications that can both import and export CGM files conforming to MIL-D-28003A. Numerous other vendors offer applications that can either import or export CGM files or can both import and export CGM files, but only in conformance with the previous version of this specification. DoD organizations planning to use a drawing application for CALS compliant illustrations should be certain that the application explicitly conforms with the import and export requirements of MIL-D-28003A. (Garner, et. al., 1994, pp. 6-8, 6-9)

2. Future of Standard

This standard was first issued in 1988 and is currently in its first revision (1991) with amendment 1 (1992). A possible evolution of the CGM standard in the CALS

environment is the definition of "intelligent graphics." This type of graphic will contain information related to the graphic, but not pertaining to the illustration itself. For example, the requirement for attaching comments about the graphic with the illustration and version control information for the illustration could be attached to a graphic file through the use of SGML tags on the illustrations. (Garner, et. al., 1994, pg. 6-6)

The international CGM standard is planning to specify three different widely used application profiles (including the MIL-D-28003A Application Profile) in its next revision (Garner, et; al., 1994, 6-4). This may alleviate the need for this standard if the international, national and federal CGM standards cover all the CALS specific illustration requirements.

E. CALS TEST NETWORK

The CALS Test Network (CTN) is an Air Force managed program used to perform testing of CALS standards and CALS implementations. CTN tests are performed by DoD and industry representatives at various testbeds at military laboratories and national laboratories. The results are published on the CALS Bulletin Board System (BBS) for review. The primary aim of these tests is to "demonstrate the CALS standards, test their effectiveness and identify needed improvements to the standards. Most of the current work to data on the CTN has been on data interchange standards, such as MIL-STD-1840A, "Automated Interchange of Technical Information." (Navy CALS RIC DTG, 1994, pg. 12-12)

The next chapter describes the Evolved Seasparrow Missile Program and its application of the CALS initiative specifications and standards in the first contract of the weapon system program.

IV. EVOLVED SEASPARROW MISSILE PROGRAM

This chapter describes the Evolved SEASPARROW Missile (ESSM) program. The ESSM is an upgrade of the RIM-7P SEASPARROW missile with added capabilities to counter anti-ship cruise missiles that have maneuvering capabilities. Background material on the weapon system is presented first, followed by a description of how the ESSM program office has applied the Continuous Acquisition and Life-cycle Support (CALS) initiative during the acquisition planning process. The chapter concludes with a description of the solicitation and source selection process for the first contract for the ESSM program: the Engineering and Manufacturing Development (EMD) Phase contract.

A. BACKGROUND

This section provides background material on the ESSM. It includes a description of the weapon system, a description of the program participants, and a description of the program schedule.

1. Weapon System Description

The original RIM-7 SEASPARROW missile programs for surface ships were outgrowths of the Naval Air Systems Command (NAVAIR) air-to-air SPARROW missile program. These programs included the Basic Point Defense Missile System (BPDMS), which employed the RIM-7M missile and the follow-on SEASPARROW missile system. This missile system later became known as the North Atlantic Treaty Organization (NATO) SEASPARROW Missile System (NSSMS), employing the RIM-7P missile. These weapon systems, while effective at first, were unable to keep pace with recent developments in anti-ship cruise missile technology.

The ESSM is a surface-to-air missile that is launched from surface ships against incoming anti-ship cruise missiles with maneuvering capabilities. An enhancement of the RIM-7P missile, the ESSM will have improvements in its rocket motor, tail control surfaces, improved guidance section, and an upgraded warhead.

2. Program Participants

This section describes the ESSM program participants within the DoN, allied nations, and potential contractors.

a. Department of the Navy

As stated previously, the SEASPARROW missile system was originally a NAVAIR program within the Department of Navy (DoN). The ESSM, however, will be a Naval Sea Systems Command (NAVSEA) program within the Theater Air Defense (TAD) Program Executive Office (PEO). Because portions of the RIM-7P missile will be used in the ESSM, configuration management and legacy technical data issues will need to be coordinated between NAVAIR Tactical Air PEO and the ESSM program office.

Outside NAVSEA, several other DoN activities will have roles and responsibilities in the ESSM program. These DoN activities are listed below:

- The Naval Air Warfare Center Weapons Station at China Lake, CA will be the Technical Director Activity and Source Selection Activity. It will be responsible for all technical aspects of the ESSM and will select the defense contractor for the ESSM.

- Port Hueneme Division, Naval Surface Warfare Center (PHD-NSWC), Port Hueneme, CA will be the In-Service Support Engineering Agent (ISEA) and the Testing and Evaluation (T & E) Agent. As the ISEA, PHD-NSWC will be responsible for receiving any technical data associated with the program and distributing it to the other government program participants. It will also be the repository for technical data and program documentation for the life-cycle of the weapon system. As the T&E Agent, PHD-NSWC will coordinate and conduct development, live-firing, operational, certification testing, as well as evaluation for the ESSM.

- Dahlgren Division, Naval Surface Warfare Center, Dahlgen, VA will be the Principal for Safety. It will be responsible for developing handling and storage and usage safety procedures for the ESSM and reviewing contractor delivered safety documentation.

b. ESSM Allied Nations

The SEASPARROW missile program has been exported to eleven allied North Atlantic Treaty Organization (NATO) countries and Australia through the Foreign

Military Sales (FMS) program. These nations became known as the NATO SEASPARROW Consortium.

The ESSM program will differ from the NATO SEASPARROW missile program in that participating nations and defense contractors in their nations will share in the development and manufacturing of the weapon system in a workshare effort. The United States' defense contractor who will act as the prime contractor will be responsible for the design and manufacture of the guidance and the warhead sections as well as the integration of the entire missile. The allied defense contractors will develop and manufacture the kinematic upgrades of the rocket motor and tail control section.

These nations (Australia, Canada, Denmark, Germany, Greece, The Netherlands, Norway, Portugal, Spain, and Turkey) have formed an ESSM Steering Committee that will meet semi-annually to review progress on the weapon system program. Additionally, these nations will share in the costs of the program beginning in fiscal year 1995. They will provide military and civilian defense acquisition personnel to the ESSM program office.

c. Potential Contractors

With the shrinking of the US defense industrial base, there are presently only two potential defense contractors with the capability to deliver a weapon system such as the ESSM. These contractors are Hughes Missile Systems Company in Tucson, AZ and Raytheon Company, Missile Systems Division located in Tewksbury, MA.

3. Program Schedule

The ESSM program schedule for the EMD Phase contract is expected to be awarded in the May-June 1995 time frame. The EMD contract encompasses the delivery of technical data packages, analysis and test reports, and an in-service support engineering package. It also includes production representative All Up Round (AUR) missiles of the upgraded RIM-7P missile for conduct of developmental and operational testing. The contract also specifies the delivery of the MK 41 Vertical Launch System (VLS) Quad-Pack Canister. This is a specially designed container that will hold four ESSMs for DDG 51, Flight IIA ships.

Following design reviews scheduled in 1996, the delivery of the first test article is expected in the first quarter of 1997. Development and certification testing will begin in the forth quarter of 1995 and continue into the next century.

Following successful development testing of the ESSM and receipt of Secretary of the Navy approval for acquisition milestone III (which is projected to occur in May 1999) it is expected that the EMD phase contract will be modified for a Low-Rate Initial Production (LRIP) Contract (approximately 200 missiles) and eventually a Full-Rate Production (FRP) Contract (4,355 missiles). The LRIP and FRP contracts will be subjected to competitive bidding.

B. ESSM ACQUISITION PLANNING PROCESS

This section describes the Evolved SEASPARROW Missile Program Executive Office's Continuous Acquisition and Life-cycle Support (CALS) Government Concept of Operations and Data Management Plan for technical data. These documents will comprise two of the annexes to the ESSM Master Program Plan (MAPP). The MAPP will be presented to the prime contractor in mid-1995 as Government Furnished Information (GFI) following award of the ESSM EMD phase contract.

1. Government Concept of Operations

The ESSM Program's Government Concept of Operations (GCO) document is still in a draft version as of January 1995. Its highlights are detailed below.

a. Scope and Applicability

This GCO is intended for use by the prime contractor and any subsystem contractors in the ESSM's preliminary design, engineering and specification design, and detail design. It applies to all technical data and information created by the contractors and the government during the life-cycle of the ESSM program. The GCO is provided as government furnished information (GFI) to potential offerors as guidance for the development of CALS capabilities.

b. Goals and Objectives

The ESSM program office intends to acquire and manage data and information associated with the ESSM in digital formats in accordance with the CALS strategies. To transition the ESSM program toward the CALS vision, nations participating in the program must adhere to the following goals and objectives:

- Employ Concurrent Engineering (CE) principles to create and store data once for use in many applications, thereby reducing development cycles and increasing efficiency;

- Designate a single point of control for creation and maintenance of technical data that will be common to multiple users thus increasing quality, accuracy, and consistency of information; and

- Use an integrated data base to provide seamless, automated access and interchange of data and information associated with the ESSM Program and participating defense industry users.

c. Contractor's Approach to CALS

The GCO details what information will be required in the Contractor's Approach to CALS (CAC). Along with the information specified in MIL-HDBK-59B, the ESSM Program Office requested that several specific issues be addressed in the CAC. These issues were:

- How an enterprise environment can be developed between the contractor and his subcontractors, suppliers, and vendors;

- Determination of access rights, limitations, and responsibilities for CALS data and products among the contractor, subcontractors, and the Government;

- Provision for the contractor's CE approach (that integrates system engineering, design, manufacturing, and logistic support functions). Where information is required to be transferred among functional areas, key functional and data relationships between processes should be identified and discussed; and

- A description of the infrastructure required to support the CE environment that generates, stores and delivers the weapon system data and information.

2. Data Management Plan

The ESSM program's Data Management Plan (DMP) is in draft form as of January 1995, specific details on the DMP in its current form are presented below.

a. Scope and Applicability

The DMP documents how the Government intends to process and manage, in digital formats, the technical data and information associated with ESSM program. It defines the roles and responsibilities of Department of Navy activities participating in the ESSM program and how they will interface with other program participants. Details of the DMP are applicable to all entities that develop and provide data and information for the ESSM.

b. Data Management Organization

Overall responsibility for data management of the ESSM Data Management Plan rests with the NATO SEASPARROW Project Office Support Engineering Manager (SEM). This office coordinates the generation of any ESSM technical data and is be responsible for the planning and management of its use. The SEM is also responsible for supervising the development of technical manuals for the ESSM.

Port Hueneme Division, Naval Surface Warfare Center (PHD-NSWC) Code 4R (Missile Systems Department) is designated the Data Manager for the ESSM program. It is responsible for development, implementation and maintenance of a technical data management system that will be able to handle ESSM technical data in digital formats. PHD-NSWC Code 4R, as the Data Manager, is responsible for entering all technical data received from the prime contractor and distributing it electronically to the various DoN activities participating in the program for comment. PHD-NSWC Code 4R will also serve as the repository for technical data and ESSM documentation for the program. Code 5B (Information Technology Department) of PHD-NSWC is designated to provide technical support to accomplish this responsibility.

c. Program Data Management

The DMP indicates that the Integrated Data Management System (IDMS) will be used during the detail design stage of the EMD Phase of the program and is

planned to be used during the transition to production and support phases of the program. Specific details on how the IDMS will be used is presented in the next chapter.

d. Data Responsibility

The DMP contains an ESSM Data Responsibility Matrix that identifies data types in the following categories: Support Engineering Plans and Reports; Support Engineering Data/Summary, System Engineering Plans and Reports; Government Furnished Equipment Program Management/Contract Status; Financial Planning; and Conference Agenda/Minutes. Within each of these data type categories a variety of program documents are listed by Contract Data Requirements List (CDRL) number. Each of these documents are coded with one or more of the responsible DoN activities associated with the ESSM Program indicating whether that activity has "view only," "comment/annotate," or "recommendations/consolidation" responsibility. This matrix also lists the office code within the Project Office that has the final approval authority for a particular document. A typical document might be "view only" by one to two activities, "comment/annotate" by six to eight activities, and "recommendations/consolidation" by one of the "comment/annotate" activities. The "comment/annotate" activity is usually either Naval Air Warfare Center Weapons Station at China Lake, CA for documents relating to technical issues; Port Hueneme Division Naval Surface Warfare Center for documents relating to testing, logistics, and configuration issues; Dahlgren Division Naval Surface Warfare Center for documents relating to safety issues; or the ESSM Program Office for documents relating to financial planning and program management.

C. ESSM SOLICITATION AND SOURCE SELECTION PROCESS

This section describes the CALS specifications and standards that are part of the ESSM EMD phase contract's Statement of Work (SoW). It concludes with descriptions of certain line items within the SoW relevant to the CALS initiative.

It is important to note the ESSM EMD phase contract Request for Proposal (RFP) fell within the 180 day "grace period" following the Secretary Perry's memorandum "Specifications & Standards - A New Way of Doing Business." This "grace period" permitted the waiver of the implementation of the policy changes for on-going solicitations or contracts. (DoD OSD, 1994, pg. 2)

The effects of the acquisition policy changes were evaluated by the ESSM Program Manager (PM). The decision was made to either alter the wording of the SoW where it called for the application of the CALS specifications and standards or request a two-year waiver for the use of the CALS military specifications and standards. These subtle changes in wording and the request for a waiver are detailed with the description of the pertinent CALS specification or standard.

1. ESSM Specifications and Standards

The ESSM program in concert with the Navy Standards Improvement Program has a goal to minimize the use of military specifications and standards if suitable commercial standards are available. The PM identified nearly 100 specifications and standards applicable to a weapon system acquisition such as the ESSM. In an effort to use performance specifications instead of military specifications and in an effort to reduce contract oversight responsibilities, the PM deleted 23 military specifications and standards and used 31 commercial standards. This left 43 existing military specifications and standards pertaining to the ESSM. These 43 military specifications and standards are related to the predecessor RIM-7P missile (11), ordinance safety (9), missile testing (6), and miscellaneous (17), including eight CALS military specifications and standards.

The ESSM EMD contract's SoW identifies eight CALS specifications and standards. These CALS specifications and standards can be further categorized as CALS Standards, CALS Data Format Specifications and Product, Process, Data Integration Standards. Each of these categories are explained in greater detail below.

a. CALS Standards

CALS standards are two military standards intended to facilitate digital data interchange between the government and a contractor. These standards require the contractor to provide technical data to the acquisition managers without linking it to a proprietary hardware platform or information system. These standards are described in further detailed below.

(1) MIL-STD-974, Contractor Integrated Technical Information Services (CITIS). This standard defines how a contractor is to provide the government

online access to technical data related to a government contract. The standard provides guidelines that the contractor must follow for updating, storing, controlling, reproducing and distributing the digital data on CITIS. (DoD CALS & EDI Office, 1994, pg. 25)

(2) MIL-STD-1840B, Automated Interchange of Technical Information.[4] This standard defines digital formats that may be used by the contractor in a CALS environment when providing technical data to the government. Useful for the exchange of technical manuals, engineering drawings and other digital data, it addresses how users in two different computer hardware and software environments may share technical data. This standard provides specific guidance on file sets and formats, data file representation standards, and file naming conventions, as well as standard header information for file exchange. Although the example in the standard uses a nine-track magnetic tape for interchange media, the standard permits the government and its contractor to select a mutually agreeable interchange media. Typical interchange media includes mini-cartridge magnetic tape or optical storage disk and depends on the computer infrastructure and technical data interchange requirements for the program participants. (DoD CALS & EDI Office, 1994, pg. 25)

b. CALS Data Format Specifications

The CALS Data Format Specifications establish the requirements for the delivery of technical data to the government. Applicable for the delivery of vector graphics, ASCII text, raster image data, and graphics metafiles, these specifications are commonly known as the "28000 series specs." The specifications were discussed in detail within Chapter III, "CALS Data Format Specifications," and are listed below:

- MIL-D-28000A(1), Digital Representation for Communication of Product Data: Initial Graphics Exchange Specification (IGES) Applications Subsets and Application Protocols;

[4]The reader should note that this standard was not included in the ESSM EMD Contract's SoW, but was presented here to provide a complete description of the two CALS standards.

- MIL-M-28001B, Markup Requirements and Generic Style Specification for Electronic Printed Output and Exchange of Text (SGML);
- MIL-R-28002B, Requirements for RASTER Graphics Representation in Binary Format; and
- MIL-D-28003A(1), Digital Representation for Communication of Illustration Data: CGM Application Profile.

c. Product, Process, Data Integration Standards

Product, Process, Data Integration Standards are intended to foster an environment of integrated design, development and manufacturing where contractor entities can work together sharing the same technical data. These concepts are the core of the CALS initiative. It is left to the acquisition manager to structure a contract to encourage the contractor, through the use of incentives, to meet these goals while fulfilling the contract requirements. These standards are described in further detail below:

(1) MIL-STD-499A, Engineering Management (Systems Engineering). This standard provides a basis for defining, performing, managing, and evaluating systems engineering processes related to defense systems acquisitions. Related to the fields of concurrent engineering, integrated product development and integrated process development, this standard requires a contractor to consider life-cycle support processes while developing a system for defense procurement. (DoD CALS and EDI Office, 1994, pg. 27)

(2) MIL-STD-973(2), Configuration Management (CM). This standard requires consistent CM practices by a contractor when developing a system for defense procurement. (DoD CALS and EDI Office, 1994, pg. 27) The ESSM PM has requested and received a two-year waiver from the Milestone Decision Authority in order to apply this military standard to the ESSM EMD phase contract.

(3) MIL-STD-1388-1A(4) and MIL-STD-1388-2B(1), Logistic Support Analysis Record (LSAR) and DoD Requirements for a LSAR. The LSAR standard requires contractors to simultaneously perform Logistic Support Analysis during the development of a defense system. This standard strives to give the DoD a unified method to require contractors to (a) make support requirements a critical part of the defense system design, (b) specify what the support requirements will be as related to the system design, (c) define what the support requirements will be when the system is used operationally, and (d) design and provide requirement support material for the defense system. MIL-STD-1388-2B(1) defines how the LSAR data should be delivered so that it may incorporated into manual logistic data and Automated Data Processing (ADP) systems. (DoD CALS and EDI Office, 1994, pp. 27-28) The ESSM PM with the new acquisition policy phrased the SoW language as "use the *guidance* of MIL-STD-1388-1A(4) and MIL-STD-1388-2B(1)" instead of directly requesting that the contractor adhere to the military standards. This nuance encourages the contractor to follow the military standard without specifically requiring him to apply the military standard.

2. STATEMENT OF WORK

This section provides details in the ESSM EMD phase contract RFP's SoW on technical data and documentation and technical publishing related line items.

a. Contractor Integrated Technical Information Services (CITIS)

The ESSM PM is committed to conducting this weapon system acquisition within the requirements of the CALS initiative. The Contractor Integrated Technical Information Services (CITIS) is a database located at the contractor site that may be accessed by authorized acquisition management and technical oversight personnel of the federal government. The definition of the telecommunications solution for the CITIS is requested to be in accordance with the CITIS CALS standard (MIL-STD-974) and the Government Open System Interconnect Protocols (GOSIP) contained in FIPS PUB 146-1.

b. Technical Manual Program

The technical documentation for the ESSM EMD phase contract is to include three technical manuals: Theory of Operations Manual, ESSM Functional Description Manual, and Explosive Ordnance Disposal Manual. These manuals shall be developed under the requirements of the Technical Manual Contract Requirement (TMCR) and the CALS requirements. Additionally, the contractor is required to provide the source data required to update the technical documentation associated with Fire Control and Launcher Systems technical manuals that will be affected by the ESSM.

This chapter has presented an overview of the ESSM program including specific details of how the ESSM program office applied the CALS initiative during the acquisition planning processes and source selection processes. The next chapter will present the information technology infrastructure available for management of ESSM technical data at PHD-NSWC, the Navy's ISEA for surface ship weapon systems.

V. INFORMATION TECHNOLOGY INFRASTRUCTURE AT THE IN-SERVICE SUPPORT ENGINEERING AGENT

This chapter presents the information technology infrastructure at the In-service Support Engineering Agent (ISEA) for the ESSM program. Port Hueneme Division, Naval Surface Warfare System (PHD-NSWC) has been designated the ISEA by the ESSM program office. This makes it responsible for numerous tasks relating to maintenance of the technical data for the ESSM during the life-cycle of the weapon system. As stated in Chapter IV, PHD-NSWC, in its role as the ISEA, will be the Data Manager during the procurement phases of the missile system.

The information technology (IT) infrastructure and the information systems available at PHD-NSWC will be crucial factors in how well PHD-NSWC will be able to perform its role as the Data Manager for the ESSM Program. The ESSM Program Office's objective is to acquire and manage technical data and documentation associated with the ESSM in digital formats in accordance with the CALS strategies. PHD-NSWC will thus be a proving ground for the CALS principals.

The Integrated Data Management System (IDMS), an information system that allows users to access and process many types of technical data on integrated technical databases from a common computer desktop environment, is presented first. Then a description of how portions of the Joint Computer-aided Acquisition and Logistics Support (JCALS) System are planned to be integrated with the IDMS to form a more capable data management system is presented.

A. INTEGRATED DATA MANAGEMENT SYSTEM

The Integrated Data Management System (IDMS) originates from an information system designed to manage ordnance alteration (ORDALT) instructions and Engineering Change Proposals (ECPs) at PHD-NSWC. The development for this system, named the Automated Documentation System (ADS), began in 1988 and was funded by Naval Sea Systems Command (NAVSEA) Productivity Investment Funds. During the development and testing of ADS, a determination was made that ADS technology could be adapted to Technical Manual (TM) change processes. A second ADS was procured by PHD-NSWC and parallel development began for integration of a technical manual processing

functionality. During the subsequent development of the two ADSs, a number of similarities between the two efforts were identified. This resulted in the decision to combine the two development efforts. The two systems, with the addition of a software module to manage Contract Data Requirements List (CDRL) in 1992, were renamed the Integrated Data Management System (IDMS). Development and implementation responsibilities for IDMS were consolidated at PHD-NSWC Code 5B00 (Technical Data - now Information Technology Department). A fully operational IDMS was developed by Scientific Applications International Corporation (SAIC) and the system has been operational since 1993. Version 2.1 is the current version. A second phase for IDMS development is planned with added functionality and further integration with other information systems.

1. System Design

IDMS' software applications have been integrated using a three-layer architecture concept. The inner-most layer is considered the system layer, consisting of the operating system and network management utilities. The middle layer is the support layer. It is comprised of six application components: (1) the Visual Programming Environment, (2) the Interface Manager, (3) the System Administration Manager, (4) the Electronic Mail and Bulletin Manager, (5) the Technical Publishing System, and (6) the Report Manager. The outer-most layer represents the application layer. It consists of the following nine user functions: (1) Document Manager, (2) Distributed Software Backplane, (3) Report Generation, (4) System Administration, (5) Tracking, (6) Review and Edit, (7) Review and Comment, (8) Graphical User Interface, and (9) Electronic Mail and Bulletin Interface. While helpful in understanding how IDMS' applications are integrated in this current version, it is not certain whether this three-layer architecture will be maintained in future phases of IDMS' development. (PHD-NSWC IDMS User's Guide, 1994, pp. C-12, C-13)

2. System Configuration

IDMS makes use of an open system architecture to integrate commercial off-the-shelf (COTS) software applications in a client-server environment. An object-oriented application development environment, Visual Programming Environment (VPE) by

Market Focus Technologies, Inc., a division of SAIC, was used to integrate IDMS' various software applications. The remainder of this section will describe IDMS' Hardware and Networking Platform, Software Platform, and User Types.

a. Hardware and Networking Platforms

IDMS consists of multiple servers, workstations, and personal computers (PCs). The IDMS servers store a particular type of document created from within IDMS or obtained from another source. They provide users on-line access to a document through a client-server access. Each server is connected to local area and wide area networks, the Central Database Server, and other IDMS servers using thick Ethernet cabling and the TCP/IP protocol. The Central Database Server allows other servers to access a central repository for all the life-cycle and routing information for a particular type of document. IDMS workstations are intended for users with management responsibilities for a particular type of document. They permit users the most functionality. An IDMS workstation is connected to the IDMS servers using thick Ethernet cabling. IDMS servers and workstations at PHD-NSWC are either Hewlett Packard (HP) 9000 series, or Sun Microsystems SPARCstation hardware. A typical IDMS user will access IDMS through a desktop PC using an X-terminal emulation software application. This permits the user to become a client on one of the IDMS servers and thus run IDMS applications on his desktop PC. A typical PC at PHD-NSWC is a 386 or 486 IBM compatible PC with four to eight MegaBytes (MB) of Random Access Memory, 180 or larger MB hard drive, fourteen inch or larger Super Video Graphics Array (SVGA) color monitor, Ethernet adapter card for local area access, and a 14.4 Megabit-per-second (Mbps) modem for wide area access. Figure 3 depicts the Integrated Data Management System Hardware and Network Platforms.

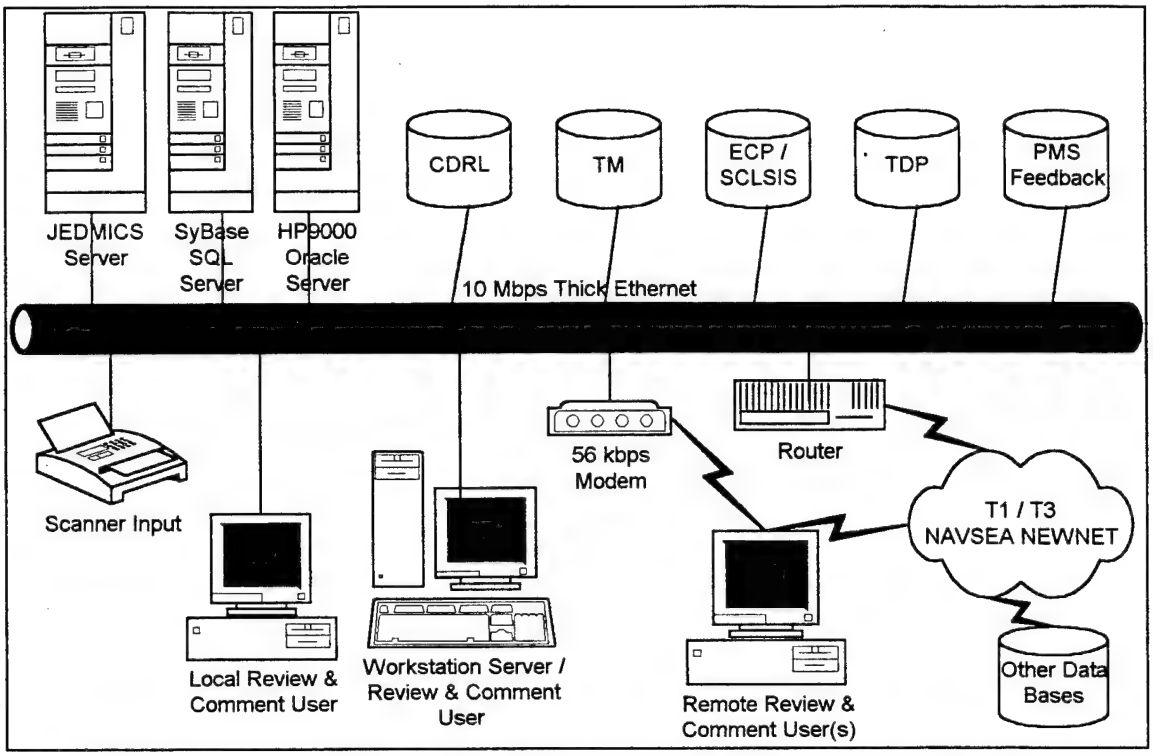

Figure 3. Integrated Data Management System

b. Software Platform

IDMS has been implemented as an integration of the UNIX operating system and the X-Windows client-server environment with numerous commercial X-Window desktop applications and database engines. IDMS workstations use either the HP-UX or SunOS UNIX operating systems. Some of the X-Windows commercial applications include: Interleaf's Interleaf 5 desktop publishing application, Worldview document interchange application, Printerleaf document printing application; Novell's WordPerfect 5.0 desktop publishing application; and Xerox Imaging System's ScanWorX document scanning application. The database engines used in IDMS include Sybase's Relational Data Base Management System (RDBMS) and Oracle's RDBMS, version 7.X.

Desktop PCs at PHD-NSWC that can function as clients on IDMS use Microsoft DOS version 6.2 and Windows for Workgroups version 3.1 for their operating systems. The local area network access is provided by Novell NetWare, which provides File Transport Protocol (FTP), telnet, and E-Mail capabilities. The X-Windows emulation application for IDMS varies among the following applications: EXCEEDW, WQR X, or

PC XVIEW. The TCP/IP protocol stack for IDMS is either Microsoft's TCP/IP from Windows for Workgroups or WQR TCP/IP. Each desktop PC at PHD-NSWC also has an array of single-user desktop software applications such as word processing, spreadsheet, graphic presentation and drawing applications. These are selected according to each user's preference and do not appear to conform to any type of standard set by the Information Technology Department at PHD-NSWC.

c. User Types

IDMS was conceived for two types of users: View and Edit users and Review and Comment users. View and Edit users are managers and technical writers who are responsible for editing technical documents such as technical manuals, technical bulletins, and advance change notices. These users may create documents on IDMS workstations at the central document processing area and route them to Review and Comment users who use their desktop PCs at their assigned work areas.

Review and Comment users are engineers and logisticians who review the various types of technical documents. These users may not alter a document that is routed to them, but they may add their recommendations and comments to a document by attaching electronic notes to the document using the Interleaf Worldview application. The electronic notes are stored in a local working file and returned to a View and Edit user once the document review has been completed.

3. System Functions

This section describes the functionality of IDMS from the perspective of the two user types. The information in this section is taken from the respective user guides for IDMS View and Edit users and Review and Comment users.

a. Technical Publishing System

The Technical Publishing System (TPS) function of IDMS allows a View and Edit user to start either the Interleaf 5 or WordPerfect 5.0 desktop publishing applications. If a View and Edit user intends to route a technical document for review, it must be processed by the Interleaf Printerleaf function and it must reside in an Interleaf Book. The Printerleaf function prepares a print image file for an Interleaf document that

becomes a static copy of the document and cannot be edited directly. The Interleaf Book function serves as a filing cabinet metaphor for storage of the Printerleaf version of the technical document and makes it accessible to other users if necessary. If WordPerfect documents need to be routed, they are first converted to Interleaf format and then processed as discussed earlier.

Currently there are no plans to integrate the Interleaf 5 <SGML>™ CALS-compliant publishing system and the associated CALS-compliant, SGML-based applications into IDMS. The primary reason for not pursuing this logical upgrade for IDMS is the refusal of Interleaf to sell their publishing system without PHD-NSWC purchasing their application integration services. Their cost for this does not seem justified. System integrators at PHD-NSWC are capable and able to perform the integration of Interleaf 5 <SGML>™ at a more reasonable cost. This situation will mean that IDMS will not receive a CALS-compliant publishing system.

b. Document Routing and Review

The Document Routing System is a custom application created by SAIC that permits a View and Edit user to route a document to Review and Comment Users. View and Edit users may assign an entire technical document or portions of a technical document to one or more reviewers, set a due data for the review, and create a report of the workload for a particular reviewer. This application does not contain any type of true workflow generation capabilities. Instead it provides a simplistic "out-and-back" routing capability. The View and Edit user is presented with a list box of potential groups and individual users within each process flow at PHD-NSWC. These process flows include ECPs, ORDALTS, CDRLs, and correspond to Interleaf filing cabinets. A manager selects one or more Review and Comment user(s) to whom the technical document should be routed according to the process flow. This system also allows a manager to de-route a document and alter the due data for a document that has been routed to IDMS Review and Comment users.

The Review and Comment users perform their functions by selecting the Review button from the IDMS desktop. This act launches the Interleaf Worldview application that permits a Review and Comment user to view an Interleaf document and submit his comments on the technical document by attaching electronic notes to the document. This is a two-step process where the Review and Comment user opens a blank

electronic note and types his textual comments, then iconifies the electronic note, and drags it to the relevant section of the document.

c. Contract Data Requirements List Definition, Tracking, and Review

Contract Data Requirements List (CDRL) Definition and Tracking are two separate functions on an IDMS View and Edit user desktop. The Definition function allows a View and Edit user to either create a new CDRL or update an existing CDRL. It also permits a user to indicate the recipients, types, and quantities of CDRL deliverables in the CDRL database. The Tracking Function permits a user to monitor the status of CDRL items for a selected contract. The CDRL Review function rests on a IDMS Review and Comment user desktop and allows one to view a "read-only" CDRL form and to attach comments using the Interleaf Worldview application.

d. Document and CDRL Comment Merge

The Document and CDRL Comment Merge system permits a View and Edit user to incorporate the comments from Review and Comment users on a technical document or CDRL. The electronic note in Interleaf Worldview is opened and a "cut and paste" operation is performed onto the technical document or CDRL form using either the Technical Publishing System or CDRL definition system, respectively.

e. Return, Mailbox, and Utilities

The IDMS Return function permits a Review and Comment user to return a technical document or CDRL to a View and Edit user after completion of his review responsibilities. The Mailbox function provides standard E-Mail capabilities to both types of IDMS users and is the primary method for View and Edit users to notify Review and Comment users of a their workload. The IDMS Utilities functions include a calendar program, electronic calculator, floppy disk utility, graphical user interface controls, password utility, and the ScanWorX document scanning application.

B. INTEGRATION OF IDMS WITH JCALS

This section describes the planned effort to integrate the Integrated Data Management System (IDMS) with the Joint Computer-aided Acquisition and Logistics Support (JCALS) System.

1. Background

The concept of a common desktop environment for the ESSM Program that permits users to interact with other program participants and permits users to access program technical data and documentation is a stated objective of the Integrated Logistics Support (ILS) Manager for the ESSM Program Office. It is thought that such a desktop environment, with common software applications and uniform access to program technical data and documentation in digital formats, will foster a work environment that is superior to one where program responsibilities are carried out with paper-based processes.

To satisfy this requirement, IDMS was proposed by PHD-NSWC as a possible candidate for a common desktop environment. IDMS had the advantages of being an almost fully implemented system. It had demonstrated functionality in CDRL definition, tracking, and review. It also could operate on a desktop PC. Some of IDMS' shortcomings included its heavy dependence on the proprietary Interleaf desktop publishing application and its associated Printerleaf and Worldview applications. It also lacked a true workflow manager application.

The JCALS system should be considered the future for the concept of a technical data management system with a common desktop environment. Still undergoing prototyping and development, the first operational systems are expected to be delivered in the first half of 1996.

In January of 1995, IDMS was demonstrated on the JCALS prototype site at PHD-NSWC. For the purposes of the demonstration, the IDMS icon was available on a JCALS workstation and provided access to the IDMS server in a window on the JCALS desktop. An IDMS View and Edit user then accessed a sample document and assigned it for review to IDMS Review and Comment users locally at PHD-NSWC and remotely at the Marine Corps Logistics Base (MCLB) in Albany, GA. The IDMS Routing and Mail systems were used. The Review and Comment users locally and at MCLB received notification of the document awaiting review by E-Mail. They then accessed the sample

document and made their comments for demonstration purposes using editing tools locally available. The document was then returned to PHD-NSWC and the sample comments were incorporated by the View and Edit user into the document. Finally, the annotated sample document was forwarded, for printing using JCALS, to the Defense Printing Service which is co-located with PHD-NSWC at the Naval Construction Battalion Station in Port Hueneme, CA. This comprehensive demonstration proved that a legacy system, like IDMS, albeit only a couple of years old, could coexist with a newer information system such as JCALS.

2. Implementation Plan

Presently, the Information Technology Department at PHD-NSWC has initiated an integration effort to incorporate portions of JCALS into IDMS. PHD-NSWC intends to purchase the GOTS portions of JCALS, namely the Workflow Manager application, Global Data Base Manager, and Reference Library. CSC will provide integration support to PHD-NSWC on a fee basis as condition of the sale of the GOTS portions of JCALS. SAIC will perform the integration effort, with a projected completion data of the latter half of 1995.

The most significant objective of the implementation plan is for the Interleaf desktop publishing application, and its associated Worldview and Printerleaf applications, to be useable with JCALS' reference library, workfolder, and Workflow Manager application. IDMS and its associated CDRL definition, tracking, and review functions are a significant portion of the ISEA's responsibilities during a weapon system program and are currently only implemented in Interleaf 5. The plan to integrate JCAL's Workflow Manager into IDMS will provide IDMS View and Edit users the ability to perform Business Process Reengineering on current procedures. This may lead to the creation of workflows for the various types of processes expected to be performed by the ISEA during the ESSM contract.

PHD-NSWC fully expects to migrate from IDMS to JCALS during the life of the ESSM contract. It is hoped that this intermediate step of integrating portions of JCALS with IDMS will ease PHD-NSWC's and other ESSM Program participant's transition to full JCALS in the future.

This chapter has presented the Integrated Data Management System (IDMS), an information system that allows users to access and process many types of technical data on

integrated technical databases from a common computer desktop environment. IDMS' strengths are its open client-server architecture, its integration with COTS applications, and its functionality in defining, tracking and reviewing CDRL data. These factors make IDMS a suitable candidate for integration with a system like JCALS that does not presently have the full functionality that is required at the awarding of the ESSM contract. Fortunately, IDMS has a generic enough nomenclature that allows it to endure as an information system that metamorphoses into a more capable integrated system.

The next chapter presents the conclusions, recommendations, and issues for further research.

VI. CONCLUSIONS AND RECOMMENDATIONS

This chapter presents some answers to the research questions addressed by this thesis and discusses several issues raised during the investigation that may warrant further research. The chapter concludes with specific recommendations related to the management of technical data for the ESSM program.

A. APPLICATION OF THE CALS INITIATIVE TO THE ESSM EMD PHASE CONTRACT

This section describes how the ESSM program office should continue to evaluate the applicability of the CALS initiative and especially its data format specifications to the ESSM EMD phase contract.

1. Conclusions

Given the recent changes in DoD acquisition policies that were brought on by Secretary of Defense, William J. Perry's memorandum, "Specifications & Standards - A New Way of Doing Business," the ESSM PM released the ESSM EMD phase contract RFP in a turbulent defense acquisition environment. It should be noted that the DoN, NAVSEA, and the ESSM program office certainly had their fingers on the pulse of the coming acquisition reforms. This was evidenced by the usage of the Navy Standards Improvement Program during the ESSM acquisition planning process. To summarize from the material presented in Chapter IV, the ESSM program office evaluated over 100 specifications and standards applicable to the ESSM program and deleted 23 military specifications and standards, substituted 31 commercial standards, and used 43 military specifications and standards including eight CALS military specifications and standards. Without question, the ESSM program office was out in front of the coming wave of acquisition reform.

Although release of the ESSM EMD phase contract RFP fell within the 180 day "grace period" offered by the Perry memorandum for ongoing solicitations and contract negotiations, the ESSM program office sought to evaluate the application of the CALS initiative military specifications and standards. Subtle changes in wording and the request of a two-year waiver for two of the CALS standards relating to Logistic Support Analysis

Records (LSARs) indicate the ESSM PM's willingness to comply with the spirit of the new acquisition policies called for in Secretary Perry's memorandum.

This research concludes that the ESSM program office should continue to monitor the applicability of the CALS initiative and its military specifications and standards in the current defense acquisition environment. Even though these CALS military specifications were applied to the EMD phase RFP and will likely be "called-out" in the contract award, they should continue to be evaluated by the ESSM program office for their applicability given the recent acquisition reforms. Until the DoD CALS & EDI Policy Office resolves how the CALS initiative will continue to exist given the current DoD acquisition environment, the ESSM PM should be prepared to reissue and possibly modify the EMD phase contract RFP if it deems that this is a prudent course of action.

This position is especially true when considering the CALS data format specifications that were presented in Chapter III. DoN activities participating in the ESSM program are unfamiliar with handling technical data in CALS-compliant formats such as SGML. Specification of contractor-delivered textual data in SGML will only present new challenges for the DoN activities that are responsible for reviewing and commenting on the technical data.

2. Issues for Further Research

This investigation determined that the changes in acquisition policies called for in Secretary Perry's memorandum placed an enormous burden on acquisition managers to seek performance or commercial standards that were equivalent to military specifications and standards. With this policy change, acquisition managers must not only be familiar with current military specifications and standards and how they are applied to a defense system procurements. Now, time consuming and manpower intensive investigations into industry practices and non-government standards must also be completed during the acquisition planning process. Further study in this area should be directed at developing some type of evaluation framework or methodology for comparing current military specifications and standards to performance, commercial, or non-government standards. Without such an evaluation framework or methodology, the alternative will be an longer acquisition time lines.

B. INFORMATION TECHNOLOGY INFRASTRUCTURE AT THE IN-SERVICE SUPPORT ENGINEERING AGENT

This section presents conclusions on several issues that have an impact on the Navy's surface ship weapon system In-service Support Engineering Agent's (ISEA) ability to perform its mission. Several issues that this investigation determined warranted further research are also presented.

1. Conclusions

The ISEA is the one Navy activity that has to "live" with the decision specifying what format technical data for a weapon system is delivered by a contractor. It is not an overstatement to assert that the effectiveness of the ISEA hinges on a decision specifying the format of the contractor-delivered technical data made during the acquisition planning process. In a budget climate where declining resources are the norm, it is unlikely that the funding to accomplish a conversion of technical data from a legacy format to a more useable format will ever be available. Such efforts, if necessary, will need to be funded from the ISEA's operating funds. This situation makes the specification of technical data formats even a more important process during acquisition planning.

The information technology (IT) infrastructure at the Navy's weapon system ISEA can and should have an impact on how an acquisition manager specifies the delivery weapon system technical data. Currently the IT infrastructure at Port Hueneme Division, Naval Surface Warfare Center (PHD-NSWC) is a heterogeneous hardware and software environment. It reflects the diversity of the various types of technical data specified during a weapon system program's life-cycle. Development of information systems, such as the Integrated Data Management System (IDMS), indicate the desire of PHD-NSWC to standardize on an open architecture for computer workstations, PCs, commercially available software operating systems (UNIX and X-Windows), and applications. While this strategy is admirable, it has not positioned PHD-NSWC to capitalize on the Navy's efforts to specify delivery of technical data in CALS-compliant data formats, especially SGML. PHD-NSWC's current effort to integrate IDMS with the government-owned software applications of JCALS is exactly the right course of action to follow. This should ease PHD-NSWC's transition to the overall JCALS infrastructure and application suite.

One of PHD-NSWC's major IT infrastructure shortcomings identified during this research, is its lack of a comprehensive enterprise-wide network architecture. Networking information systems with client-server architectures using Thick Ethernet cabling limits an information system's potential and places a ceiling on the types of data that may be processed at a user desktop. As technical documentation such as technical manuals evolve to Interactive Electronic Technical Manuals (IETMs), the existing network architecture will not support such resource intensive requirements. IETMs contain drawings, graphics, and multimedia features that are interactively linked and will require high data transfer rates to the technical writer's client application from hypermedia servers. Additionally the existing network architecture makes it difficult to institute the processing of classified technical data and business-sensitive documentation. One alternative is to consider subdividing the existing network into sub-nets that serve functional processes within PHD-NSWC.

2. Issues for Further Research

The most pressing issue for further research related to PHD-NSWC's IT infrastructure is its lack of an enterprise-wide network architecture. Clearly a significant effort must be made to design a network architecture that will support the requirements of PHD-NSWC. The second issue requiring further research is the development of workflows that reflect the ISEA's functional processes being carried out with digital technical data formats instead of paper-based formats. Once the modeling of workflows has been accomplished, they should be created on JCALS' workflow manager application and tested if possible. Once the integration of IDMS and JCALS is complete, it should facilitate the transition to accomplishing ISEA responsibilities entirely with digital technical data formats.

C. DATA MANAGEMENT PLAN FOR THE ESSM PROGRAM

This section points out several criticisms of the Data Management Plan (DMP) for the ESSM program as it stands in its current draft form. Specific recommendations on how the DMP could be improved to better reflect how the Government intends to manage technical data are also presented.

1. Conclusions

The Data Management Plan (DMP) as it stands in its current draft form is too specific in some areas and very general in other areas of technical data management. For example, the DMP focuses on the use of the Integrated Data Management System (IDMS) to such a degree that it explicitly describes the functionality of the system. However, the DMP does not address core technical data management tasks. One such task is how ESSM documentation will be controlled by the ESSM Data Manager. For instance, there is no discussion in the DMP of a document version numbering scheme. Additionally, the DMP in its current form does not address the exchange of classified technical data and business-sensitive ESSM documentation. Although it asserts that IDMS must be capable of transmitting and receiving classified technical data such as engineering drawings, specific security procedures have yet to be developed.

2. Recommendations

The core recommendations that this research makes are directed at how the Data Management Plan could be improved to reflect issues relating to the management of technical data. The draft Data Management Plan is an annex to the Master Program Plan (MAPP) which is expected to be completed by mid-1995. At that time the entire MAPP will be presented to the ESSM prime contractor. The draft Data Management Plan at the time of this writing was being reviewed and commented on by each of the Navy activities participating in the ESSM Program. It is a plausible conclusion that many of the issues presented below may already have been incorporated in the final version of the DMP. This investigation, because of time constraints, did not have access to the preliminary comments.

The remainder of this section presents recommendations on issues that a DMP should address to fully describe to the contractor how the Government intends to manage technical data.

a. Technical Data Working Group

First, it is recommended that the ESSM PM establish a Technical Data Working Group that meets regularly to discuss technical data matters. Membership in the group should include representatives from technical, logistic, program management, and

information technology management fields. The Technical Data Working Group would be responsible for identification of technical data types, processes, and management systems. Each of these responsibilities is described below.

b. Identification of Technical Data Types

One of the first responsibilities of the Technical Data Working Group is to identify the various technical data types that will be used during the life-cycle of the weapon system. This begins with the determination of what legacy technical data exists and whether it will be used for the new weapon system. At this time, a decision must be made on whether to retain the legacy technical data in its current format or to convert it to a different format that takes advantage of current technology. An issue for consideration is how the new technical data will be identified if legacy data is used to generate new technical data? For instance, if a legacy engineering drawing is used as a starting point to create a new drawing for a weapon system, at what point is the new drawing considered a whole new drawing rather simply a modification of the legacy drawing?

The Technical Data Working Group is also responsible for identifying what technical data types will be generated by the contractor. Ideally this responsibility is acted upon very early in the acquisition planning process, since it would constitute an input to the weapon system contract SoW and the generation of CDRLs. This responsibility requires complete familiarization of the CALS initiative military specifications and standards. Since the Secretary of Defense memorandum now directs that the CALS military specifications and standards be viewed as guidance by acquisition managers, this requires that working group members investigate performance, commercial, and non-government standards that yield technical data or processes that are equivalent to what the CALS military specifications and standards would have yielded.

c. Identification and Description of Technical Data Processes

Once the Technical Data Working Group identifies the technical data types, each of the necessary technical data processes should be identified and described. The perspective for identifying these technical data processes should be from the program participant's responsibilities during management of the weapon system contact. The

description of how the technical data processes should be carried out should be as complete as possible. Below is a recommended list of sample technical data processes:

- Data Submission is the process by which technical data is forwarded to the weapon system Data Manager. This process as a minimum should identify what methods and which protocols are to be used.

- Data Access and Views refer to how the Data Manager will provide access to program technical data to other program participants. This process should identify how classified technical data and business-sensitive documentation may be accessed and viewed by program participants. It should include what rules are in effect and what viewer applications will be used for technical data and program documentation.

- Data Routing is the process by which program technical data will be transferred among program participants. Transferring of technical data and program documentation refers to what method and which protocol will be in effect. It includes how classified technical data and business-sensitive program documentation will be handled.

- Workflow Generation is the process of translating current acquisition processes into workflows using Business Process Reengineering principles, if this has not already been done. A complete detailing of who will be responsible for creating, monitoring, and canceling particular classes of workflows, what workflow applications will be used, and what workflow conventions will be followed should be included.

- Data Manipulation and Enhancement refer to the processes by which technical data and program documentation is altered or commented upon. This process should include who will be assigned such duties, how this task will be carried out, and what application will be used.

- Data Ownership and Storage will be the overall responsibility of the program Data Manager. It should address how technical data will be controlled (i.e. version control) and how it will be stored in a technical data repository.

d. Technical Data Management Systems

Technical Data Management Systems are the information systems that are projected to be used during the life-cycle of the weapon system program to handle technical data and program documentation in digital formats. This section should not

explain in detail how the data management systems will perform the necessary technical data processes. Instead it should address how the system will be administered and how the system will be deployed among program participants. The types of information systems can be categorized into legacy systems, CALS infrastructure modernization systems, and contractor furnished systems. These three types of systems are explained below:

- Legacy systems are information systems that are currently in use or under development at Navy activities participating in the weapon system program. This section should acknowledge the existence of these systems and describe whether they are compatible with the program's needs. Additionally, migration options to the CALS infrastructure modernization systems or to another information system should be discussed here.

- CALS infrastructure modernization systems refer to the Joint Computer-aided Acquisition and Logistics Support (JCALS) system and the Joint Engineering Drawing Management Information Control System (JEDMICS). This section should address whether either of these systems are available for program participants or how program participants may eventually migrate their technical data and processes to these systems.

- Contractor furnished systems refer to either the CALS military specification for a Contractor Integrated Technical Information Services (CITIS) system, or a proprietary contractor developed system, or a commercial off-the-shelf system if available. This section should acknowledge the existence of these types of systems and describe whether they are compatible with the program's needs.

This chapter has presented conclusions on why the CALS initiative and its data format specifications should be reviewed as to their applicability to the ESSM Engineering and Manufacturing Development phase contract. It should be recognized that a tremendous effort by ESSM program acquisition managers was put forth to developing and issuing the EMD phase contract RFP. Clearly these individuals were faced with challenging issues in a changing DoD acquisition environment. Application of the CALS military specifications and standards to this weapon system acquisition was a major step in the acquisition planning process.

Conclusions on why the Navy's weapon system ISEA should figure prominently when acquisition planners specify contractor-delivered technical data have also been presented. Issues requiring further research including the ISEA's IT

infrastructure especially an enterprise-wide network architecture and reengineering of ISEA technical data processes have been described. It is hoped that the recommendations on how a Data Management Plan could be structured will be helpful to acquisition managers during the acquisition planning processes for future weapon systems.

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